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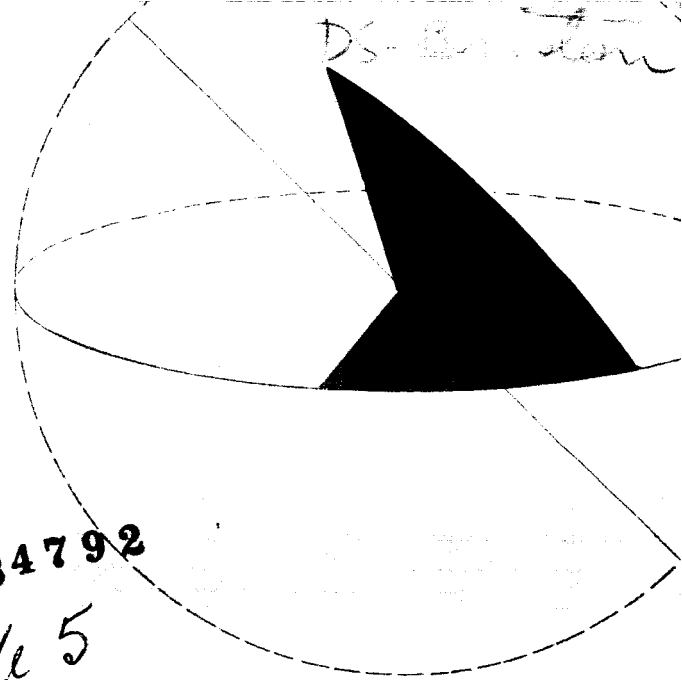
**LITERATURE  
SEARCH NO. 230**

**COSMIC RAY  
MEASUREMENTS AND  
MEASURING DEVICES**

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**ASTRONAUTICS INFORMATION**

LITERATURE SEARCH No. 230

**COSMIC RAY MEASUREMENTS  
AND MEASURING DEVICES**

Esther Pereira

Jan. 1960 89 p

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California  
January 1960

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## FOREWORD

A survey was made of the periodical and report literature published on Cosmic Rays with emphasis on Čerenkov radiation.

The material has been divided into two main categories: General Information and Čerenkov Radiation, with subheadings of Theory, Instrumentation and Measurements. Under each subject heading reports have been arranged in alphabetical order by source, books in alphabetical order by author, and periodicals alphabetically by journal name.

The following sources have been consulted: *JPL Astronautics Information/Abstracts* 1958–1960; *JPL Astronautics Information/Survey* 1958–1960; *Nuclear Science Abstracts (NSA)* 1958–1959; *Physics Abstracts (PA)*, 1958–1959; Armed Services Technical Information Agency (ASTIA), Technical Abstract Bulletins 1958–1959.

## **PREFACE**

The technical staff of the Jet Propulsion Laboratory library is engaged in an extensive literature searching program covering subjects selected by the Laboratory engineers and designed to meet their individual needs. Searches considered to be of interest to persons working in the field of astronautics will be published for distribution to interested organizations.

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## I. GENERAL INFORMATION

### A. Theory

#### Reports

#### 1. THE ORIGIN OF COSMIC RAYS (USSR)

Ginzburg, V. L. and Fradkin, M. I.

June 25, 1959

U.S. Joint Publications Research Service,  
Washington, D.C.

(Translated from *Priroda*, no. 8, pp. 3–12, August 1958)

#### Books

#### 2. COSMIC RAY VARIATIONS

(“Variatsii Kosmicheskikh Luchey”)

Dorman, L. I.

(Translated from a publication of the State  
Publishing House for Technical and Theoretical  
Literature, Moscow, 1957, NP-tr-82 (736 pp.))

The experimental and theoretical methods of investigating the variations of cosmic rays (time variations of their intensity) are given, the accumulated experimental material is systematized and analyzed, and the hypotheses proposed for the origin of various types of variations are critically considered. A theory is proposed for the origin of the variations, and their correlation with various geophysical and astrophysical phenomena is examined, in particular their correlation with the properties of the solar corpuscular streams and with the electromagnetic conditions in the neighborhood of the Earth, in the solar atmosphere, in interplanetary space, and in the galaxy. The book is intended for scientists occupied with cosmic-ray physics, astrophysics, geophysics, or meteorology, for students of advanced courses in these specialties, and for workers in the network of stations for continuous cosmic-ray observations. (NSA, v. 12, #9889)

#### 3. PROGRESS IN ELEMENTARY PARTICLE AND COSMIC RAY PHYSICS

Volume I and II, 1954; Volume III, 1956; Volume IV, 1958; Volume V, 1960

Wilson, J. G. and Wouthuysen, S.A., Editors  
North-Holland Publishing Co., Amsterdam

Chapters are included on: some theoretical aspects of the strong interactions of the new particles; the properties and production of K mesons; the interactions of  $\mu$ -mesons with matter; the primary cosmic radiation and its time variations; and the origin of cosmic radiation. (NSA, v. 12, #10,000)

#### Periodicals

#### 4. SOME SOVIET THOUGHTS ON TAPPING THE ENERGY OF COSMIC SPACE

Pokrovskiy, G. I.

*Air Force and Space Digest*, v. 42, no. 4, pp. 124–125,  
April 1959

#### 5. ON THE POSSIBILITY OF PREFERENTIAL ACCELERATION OF HEAVY ELEMENTS IN COSMIC RAY SOURCES

Korchak, A. A. and Syrovatskii, S. I.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 122,  
pp. 792–794, October 11, 1958

#### 6. NEW MECHANISM OF RELATIVISTIC ELECTRON PRODUCTION IN THE COSMIC SPACE

Veksler, V. I.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 118,  
pp. 263–265, January 11, 1958

It is shown that the motion of quasi-neutral bunches of totally ionized plasma in a heterogeneous magnetic field should be followed (under certain general conditions) by production of relativistic electrons. Analysis is made of a limited bunch of quasi-neutral plasma composed of equal numbers of positive ions and electrons with a total transition velocity  $v_0$  and initial velocity  $v_0 < c$ . The case considered corresponds to the quasi-neutral bunch reflection in a magnetic field at 180 deg. However, the qualitative analysis convincingly demonstrates the mechanism by which any motion of the quasi-neutral bunch in a heterogeneous magnetic field (in addition to other processes) will result in the energy transition from the heavy fraction of the bunch to the light one. (NSA, v. 12, #9891)

**7. RADIOASTRONOMICHESKIE ISSLEDOVANIA  
S POMOSCHCHIU ISKUSSTVENNYKH  
SPUTNIKOV ZEMLI**

Getmantsev, G. G., Ginzburg, V. L., and  
Shklovskii, I. S.

*Akademii Nauk, SSSR, Uspekhi Fizicheskikh Nauk*,  
pp. 157–161, October 1958

The importance of satellite data in obtaining information on the electron component of cosmic rays leading to the determination of the density of interplanetary gas is discussed. Such problems as the selection of apparatus, the type of antenna best suited for satellite installation, weight requirements, the effect of satellite rotation on the orientation of antennas, and the effect of interference are analyzed.

**8. THE ORIGIN OF COSMIC RAYS**

Ginzburg, V. L.

*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk*  
(in Russian), v. 62, no. 2, pp. 37–98 (1957)

The article discusses the radical changes that were made to cosmic ray theory during 1948–1950 (when, to a first approximation, the composition of the primary cosmic rays at the Earth was accounted for) and 1950–1953 (radioastronomical data concerning the distribution of cosmic rays in the galaxy and beyond). The four main sections are concerned with: primary cosmic rays at the Earth; the magnetic retardation nature of cosmic radio-emission, and the distribution of cosmic rays in the galaxy; the motion of cosmic particles in an interstellar medium; supernovae and new stars as sources of cosmic rays. Contains 75 ref. (33 Soviet). (PA, v. 61, #5087)

**9. ORIGIN OF COSMIC RAYS AND RADIO  
ASTRONOMY**

Ginzburg, V. L.

*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk*,  
v. 51, no. 3, pp. 343–392, 1953  
(Abstracted in *Technical Translations*, v. 2, no. 12,  
p. 836, December 18, 1959)

**10. COSMIC RADIATION**

Scarsi, L.

*American Journal of Physics*, v. 28, no. 3,  
pp. 213–220, March 1960

This paper gives some general information about cosmic rays, especially with regard to the properties of the primary flux: charge composition, energy spectrum, and time variations.

**11. THE PRIMARY RADIATION**

Neher, H. V.

*Annual Review of Nuclear Science*, v. 8,  
pp. 217–242, 1958

**12. THE SUN AS A SOURCE OF COSMIC RAYS  
OF INTERMEDIATE ENERGIES**

Katzman, J.

*Canadian Journal of Physics*, v. 37, no. 11,  
pp. 1207–1215, November 1959

**13. POSSIBILITY OF FORECASTING SOLAR  
PHENOMENA AND THEIR EFFECTS AT  
THE EARTH BY THE STUDY OF  
COSMIC-RAY INTENSITY**

Legrand, J. P.

*Comptes rendus hebdomadaires des séances de  
l'académie des sciences* (in French), v. 247, no. 1,  
pp. 70–73, July 7, 1958

Some evidence is given, that solar chromospheric eruptions, which are followed by geomagnetic and ionospheric disturbances, and a decrease in cosmic-ray intensity, are also preceded, 24–48 hours earlier, by a 1–3 percent decrease in cosmic-ray intensity. (PA, v. 61, #8093)

**14. THE EMISSIONS OF TYPE IV AND THE  
ORIGIN OF COSMIC RAYS ASSOCIATED  
WITH SOLAR FLARES**

Boischot, A. and Denisse, J. F.

*Comptes rendus hebdomadaires des séances de  
l'académie des sciences* (in French), v. 245, no. 25,  
pp. 2194–2197, December 16, 1957

The general characteristics of solar bursts of Type IV, observed on meter wavelengths, find an explanation in terms of electrons emitted from the flare with relativistic energies in the presence of a magnetic field, giving synchrotron radiation. Typical conditions are  $\sim 10^{32}$  electrons with mean energy 3 Mev in a magnetic field of



1 gauss. The relationship between this type of burst and the emission of cosmic radiation by the Sun is discussed. (PA, v. 61, #2736)

**15. COSMIC RADIATION: THE PRIMARY PARTICLES**

Wilson, J. G.

*Contemporary Physics*, v. 1, no. 3, pp. 204–219, February 1960

Observations of primary cosmic-ray particles entering the upper atmosphere show that the solar system is situated in an isotropic flow of protons and of heavier nuclei, and that these particles carry energy which can vary from small values to values so great that at present the upper limit of energy carried by a single particle cannot be defined.

**16. A GALACTIC MODEL FOR PRODUCTION OF COSMIC RAYS AND RADIO NOISE**

Marshall, L.

*IRE, Proceedings of the*, v. 46, no. 1, pp. 215–220, January 1958

A model for a galaxy with observable spiral arms is proposed. The magnetic field of the spiral arms, together with a magnetic halo which is a natural extension of the field of the arms, make the parts of a Fermi accelerator for charged particles. The particle energies are such that the high-energy tail approximates a cosmic-ray spectrum, while the lower-energy particles account for the radio radiation of the galaxy. The accelerating process depends upon fluctuations of magnetic lines of force due to disturbances in the halo. A semi-quantitative analysis of the theory is made, and results compared with radio observations of spirals and with observations of 21 cm radiation in the galaxy, especially wavelength shifts. (PA, v. 61, #5579)

**17. MAGNETIC CUTOFF RIGIDITIES OF CHARGED PARTICLES IN THE EARTH'S FIELD AT TIMES OF MAGNETIC STORMS**

Rothwell, P.

*Journal of Geophysical Research*, v. 64, no. 11, pp. 2026–2028, November 1959

**18. COSMIC-RAY TRAPPING IN INTER-PLANETARY SPACE**

Beiser, A.

*Journal of Geophysical Research*, v. 63, no. 1, pp. 1–17, March 1958

The existence of long-term variations in cosmic-ray intensity negatively correlated with sunspot activity, was explained by Davis (PA, v. 59, #2217) in terms of a cavity in the galactic magnetic field centered about the Sun. In the present paper, it is shown that a “diamagnetic” interplanetary region, rather than a “super-conducting” one, can account for the cutoff in the primary cosmic-ray rigidity spectrum, as well as for the 11-year variations. The suggested diamagnetic region is an oblate spheroid in shape, with semiaxes of roughly  $5 \times 10^{15}$  cm and  $5 \times 10^{14}$  cm, and its effective permeability of  $10^{-9}$  implies a mean interplanetary field of about  $10^{-9}$  gauss. The 11-year variations and the rigidity cutoff are analysed in detail on the basis of this model. (PA, v. 61, #5096)

**19. CHANGE OF COSMIC RAYS IN SPACE**

Neher, H. V.

*Nature*, v. 184, no. 4684, pp. 423–425, August 8, 1959

**20. COSMIC DUST IN THE ATMOSPHERE**

Parkin, D. W. and Hunter, W.

*Nature*, v. 183, no. 4663, pp. 732–734, March 14, 1959

**21. DIFFERENCE BETWEEN COSMIC-RAY EQUATOR AND THE GEOMAGNETIC DIP EQUATOR**

Oguchi, T. and Kodama, M.

*Nature*, v. 183, no. 4654, p. 103, January 10, 1959

**22. ENERGY SPECTRUM OF PARTICLES BOMBARDING THE EARTH**

O'Brien, B. J.

*Nature*, v. 181, no. 521, August 23, 1958

In the energy region above  $10^9$  ev, cosmic rays follow an integral energy ( $E$ ) spectrum given by  $N \propto E^{-1.5}$ . It is pointed out that the estimated fluxes of interstellar and auroral particles appear to fit the straight-line portion of this spectrum extrapolated to lower energies. (PA, v. 62, #1573)

**23. COSMIC RAYS AND THE SUNSPOT CYCLE**

Winckler, J. R. and Peterson, L.

*Nature*, v. 181, no. 4619, pp. 1317-1319,

May 10, 1958

**24. PRIMARY  $\alpha$ -PARTICLE INTENSITY AT SUNSPOT MAXIMUM**

Freier, P. S., Ney, E. P. and Fowler, P. H.

*Nature*, v. 181, no. 4619, pp. 1319-1321, May 10, 1958

**25. ENERGY SPECTRUM OF COSMIC RADIATION**  
Åström, E.

*Nature*, v. 181, pp. 330-331, February 1, 1958

The spectrum of cosmic radiation has the property that it is a power function  $f = \text{const} \times p^{-n}$  (where  $p$  is momentum) where  $n$  has a constant value of about 2.5 for several powers of ten of  $p$ . The assumptions made to obtain an empirical formula are implausible. However, it is shown that a power law can be obtained if it is assumed that particles, which are injected at low energies, are pumped up to higher energies by a pump the speed of which is a power function of the momentum. Hence, all cosmic-ray particles move up through the energy spectrum in a more or less systematic way, and the time they spend in a certain energy range is inversely proportional to the speed of the pump. (NSA, v. 12, #5428)

**26. THEORY OF THE COSMIC RAY EQUATOR**

Ingraham, R.

*Nuovo cimento*, II, v. 12, no. 4, pp. 356-368,

May 16, 1959

The  $45^\circ$  westward shift of the cosmic-ray equator from the geomagnetic equator is explained by assuming that there exist ionized atmospheric layers which rotate more slowly than the Earth. The resultant magnetic field beyond the layers is then a dipole field whose magnetic north pole is west of the familiar geomagnetic north pole. The condition that this longitudinal shift be  $45^\circ$  determines  $\Delta\omega \equiv \omega' - \omega$  as a function of certain radial moments of the conductivity of the layer ( $\omega'$ ,  $\omega$  = rotational velocities of layer and Earth, respectively). The effect would vanish if either  $\Delta\omega = 0$  or if the Earth's intrinsic dipole axis were not tilted. (PA, v. 62, #8266)

**27. POSSIBLE EXPLANATION OF THE RADIATION OBSERVED BY VAN ALLEN AT HIGH ALTITUDES IN SATELLITES**

Kellogg, P. J.

*Nuovo cimento*, II, v. 11, no. 1, pp. 48-66,

January 1, 1959

The author considers the possibility, suggested by P. Rothwell and T. Gold, that at high altitudes the radiation observed by Van Allen and co-workers is due to the decay electrons and protons from neutrons produced in the Earth's atmosphere by cosmic rays and stored in the Earth's magnetic field. Order of magnitude estimates for the densities to be expected are presented and only scattering loss is considered. Using a lifetime of  $3 \times 10^9$  sec for loss through scattering, an upper limit of  $10^{-2}$  electrons/cm<sup>3</sup> near the Earth and  $0.05(R_E/r_0)^3$  electrons/cm<sup>3</sup> at large distances  $r_0$  in the equatorial plane is obtained. The proton density at large distances is  $0.03(R_E/r_0)^3$  cm<sup>-3</sup>, for a lifetime of  $10^{12}$  sec. If plasma accelerations are not important, then the spectrum of electrons will be that of neutron  $\beta$ -decay. The protons are produced by fast neutrons coming directly from nuclear stars and their spectrum will be approximately that of the protons from stars. The electron density is sufficient to give a counting rate a few times larger than is observed, while the proton density is sufficient to give a counting rate  $10^4$  times higher than the observed lower limit. The lifetimes of stored particles are therefore probably much less than those given by scattering. There should be a strong latitude effect which is roughly estimated as proportional to  $\cos^6 \lambda$ . Reasons are given for believing that collective effects will reduce the density below this near the poles. (PA, v. 62, #3613)

**28. ON THE ENERGY DETERMINATION OF THE HEAVY PRIMARIES**

Garelli, C. M., Quassiat, B., and Vigone, M.

*Nuovo cimento*, II, Series 10, v. 8, pp. 731-739,

June 1, 1958

The formula suggested by Peters for the energy determination of the heavy primaries, requires the knowledge of the mean energy of evaporation of the  $\alpha$  particles. The present work establishes that this energy depends slightly on the size of the evaporating nucleus. (NSA, v. 12, #15,631)

**29. THEORETICAL STUDY OF THE COSMIC RAY EQUATOR**

Kellogg, P. J. and Schwartz, M.  
*Nuovo cimento, II*, v. 8, no. 4, pp. 761-768,  
August 16, 1959

**30. COSMIC-RAY EVIDENCE ON THE ORIGIN OF METEORITES**

Singer, S. F.  
*Nuovo cimento, II*, v. 8, no. 4, pp. 539-548,  
May 16, 1958

The birth of a meteorite coincides with the break-up of its parent body and also with the beginning of the meteorite's exposure to cosmic rays. This continued exposure creates through nuclear evaporations definitely calculable amounts of  $\text{He}^3$ , about  $\frac{2}{3}$  of it by way of tritium. Hence, the date of break-up can be obtained from the  $\text{He}^3$  content; or better still, from the  $\text{He}^3$  and tritium content measured in the same sample. However, the latter method has only limited applicability. The two methods give good accord; of six meteorites dated, all are found to be about 300 million years old. This agreement establishes confidence in the calculations of the  $\text{He}^3$  production rate and leads to some considerations concerning the process of nuclear excitation. The age is also in good accord with Öpik's calculation of the mean lifetime of meteorite-like bodies against capture by the inner planets. From this agreement conclusions can be drawn concerning the mechanism of meteorite creation and concerning the relative constancy of cosmic-ray intensity as far back as 300 million years. (PA, v. 61, #5582)

**31. THE SIMPLE CONES OF ALBEDO OF COSMIC RAYS**

Gall, R. and Lifshitz, J.  
*Nuovo cimento, II*, Series 10, v. 7, no. 5, pp. 601-606,  
March 1, 1958

Simple albedo cones for five points of incidence were evaluated for different proton energies. The latitude, longitude and energy effects are discussed. Some results are compared with those of Schremp. The altitude, above which the interaction with the atmosphere does not invalidate the results, is given. The validity of the albedo model for different altitudes is discussed. The points of emission were studied. (PA, v. 61, #2377)

**32. NEUTRON YIELD FUNCTIONS FOR THE NUCLEONIC COMPONENT OF COSMIC RADIATION**

Brown, R. R.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 956-962,  
October 1957

In view of recent proposed changes of cosmic ray geomagnetic co-ordinates and primary spectra, calculations have been made to determine if the yield function for the nucleonic component of cosmic radiation introduced by Fonger is in need of revision. As a result of these calculations, a modified form of Fonger's yield function is proposed for calculations with the revised spectra and coordinate system. The implications of this modification for the spectra of solar flare radiation are considered. (NSA, v. 12, #4263)

**33. ON THE ANALYSIS OF THE COSMIC RAY JETS**

Huzita, H.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 841-849,  
October 1957

A new method for analyzing cosmic ray jets is presented which is independent of the angular fluctuations of secondary particles for each event. Two events are analyzed by this method and discussed. (NSA, v. 12, #4262)

**34. ON HEAVY PRIMARY CASCADES**

Hillier, R. R. and Waddington, C. J.  
*Nuovo cimento, II*, v. 6, no. 2, p. 403, August 1957

Points out that the anomalously short mean-free-paths reported recently are probably due to the limited thickness of the detecting emulsions. (PA, v. 61, #217)

**35. COSMIC RAY EXCHANGES BETWEEN GALACTIC HALO AND CENTRE**

Johnson, M.  
*Observatory, The*, Great Britain, v. 79, no. 910,  
pp. 109-111, June 1959

**36. COSMIC RAY CUT-OFF RIGIDITIES AND THE EARTH'S MAGNETIC FIELD**

Quenby, J. J. and Webber, W. R.  
*Philosophical Magazine, The*, v. 4, no. 37, pp. 90-113,  
January 1959

Approximate values of the vertical cut-off rigidities for cosmic ray particles in the Earth's magnetic field have been deduced taking into account both the dipole and the non-dipole parts of the internal field.

### 37. COSMIC RAYS IN THE EARTH'S MAGNETIC FIELD.

Rothwell, P.

*Philosophical Magazine, The, Eighth Series*, v. 3, pp. 961-970, September 1958

It is shown that the values of cosmic ray cut-off momenta in the Earth's magnetic field, observed at many different places, are generally close to the values calculated from Störmer's theory for the motion of charged particles in a dipole field, if the usual center dipole of the Earth is replaced in the Störmer equation by a dipole whose magnitude and direction are determined by the surface field at the place considered. An empirical expression for the actual cut-off momenta (in terms of the center-dipole field, and the "surface field" cut-off momenta) is deduced from the variation in sea-level nucleon intensity between London and Cape Town, and gives good agreement with experimental results over a wide range of latitudes and longitudes. It is concluded that discrepancies between center dipole predictions and experimental observations of cosmic ray intensities and cut-off momenta are due to differences between the Earth's real field and the dipole approximation to it, rather than to distortion of the Earth's outer magnetic field by ionized interplanetary matter. (NSA, v. 12, #16,464)

### 38. FLUX AT SEA LEVEL OF HEAVY CHARGED PARTICLES PAIR-PRODUCED IN COSMIC RAY SHOWERS

Goldberg, A.

*Physical Review, The*, v. 117, no. 4, pp. 1128-1129, February 15, 1960

The flux at sea level of charged particles with mass 300-600 electron masses is calculated assuming the particles to be pair-produced by cosmic ray photons.

### 39. ACCELERATION OF COSMIC RADIATION

Murty, G. S. and Varma, R. K.

*Physical Review, The*, v. 112, no. 5, pp. 1789-1792, December 1, 1955

Alfvén's model of discontinuous magnetic field variations for the acceleration of cosmic rays by the betatron

mechanism is generalized to continuous field variations, with special reference to sinusoidal fields. It is shown that the efficiency of this model is maximum when the "rate of randomization" is equal to the frequency of oscillation of the magnetic field. Also the maximum efficiency is comparable with those of Alfvén's and Parker's models. (PA, v. 62, #2008)

### 40. INTERPLANETARY MAGNETIC FIELD AND ITS CONTROL OF COSMIC-RAY VARIATIONS

Piddington, J. H.

*Physical Review, The*, v. 112, no. 2, pp. 589-596, October 15, 1958

A model interplanetary magnetic field is described which may explain some features of solar cosmic-ray increases and also fluctuations in the primary radiation. The main features are as follows: (1) A chromospheric "explosion" occurs at the time of a flare in gas permeated by the sunspot field. The gas, linked with magnetic flux  $< \sim 10^{21}$  gauss cm<sup>2</sup>, is ejected from the vicinity of the Sun. (2) The gas and field remain linked and the latter is so distorted that solar cosmic-rays are released  $\sim \frac{1}{4} - 1$  hour after the flare. (3) The trailing radial field is drawn out past the Earth's orbit to form a magnetic cone with closed ends. The life of the interplanetary field is at least a few months and a number of segments may be built up from different spot fields. The general field may contribute, being extended to largely radial form by a general outward movement of gas. (4) Cosmic rays released after one flare may be influenced by the radial field resulting from a previous flare associated with the same, or perhaps a different, spot group. (5) On February 23, 1956, the magnetic cone enclosing the Earth contained irregularities separated by  $\sim 0.5$  astronomical unit, capable of deflecting 15 Bev protons up to  $\sim 20^\circ$  and completely scattering 1.5 Bev protons. Cosmic ray diffusion was anisotropic, the rate being  $\sim 65$  times greater along the field than across the field. The main features of the solar increase may be explained by such a field. (6) Some observed variations of primary cosmic radiation (Forbush-type decreases, 27 day and diurnal variations) may be qualitatively explained by the model. (7) The model may explain aurorae in terms of ions of intermediate energy ( $\sim 10^5$  ev) transported from the Sun in the magnetic cone which reaches the Earth in a day or two and may inclose it for many days or weeks. (PA, v. 62, #2007)

crests of the waves are a natural consequence of the observed supersonic mass motions. Therefore, the acceleration by oppositely moving waves does not depend upon any special waveform, and it is suggested that it is the naturally occurring acceleration process. By treating the cosmic rays as a gas with relativistic thermal motions, it is shown that the cosmic-ray gas is effectively coupled to the motions of the ordinary matter both parallel and perpendicular to the magnetic field. Thus, the effective speed of sound must be computed in the composite cosmic-ray and ordinary gas. It is noted that with this composite speed of sound the irregular mass motions in the galactic disk and halo are approximately Mach one. It is suggested that this represents a general dynamic balance to be found in all sufficiently active regions of space, and explains how it is that one often observes prolonged mass motions in the galaxy and in stellar atmospheres which would otherwise be computed to be highly supersonic and dissipative. The dynamic balance comes about from the fact that increased cosmic-ray density would reduce the effective Mach number below one, allowing the sharp crests of the hydromagnetic waves to degenerate, and thereby halting the production of cosmic-ray particles. (PA, v. 61, #1452)

#### 45. POLARIZATION OF COSMIC-RAY $\mu$ MESONS: THEORY

Hayakawa, S.

*Physical Review, The*, v. 108, no. 6, pp. 1533-1537, December 15, 1957

The expected polarization of cosmic-ray  $\mu$ -mesons is calculated on the basis of the two-component theory of the neutrino. The polarization is found to reveal the energy spectrum of  $\pi$ -mesons which decay into  $\mu$ -mesons at high altitudes, provided that the depolarization on penetration through the atmosphere is known. The depolarization caused by the Coulomb scattering is estimated to be several percent and practically independent of the energy of  $\mu$ -mesons at production. The depolarization in the absorber is found to be negligible. (PA, v. 61, #1749)

#### 46. ATMOSPHERIC SIGNALS CAUSED BY COSMIC-RAY SHOWERS

Wilson, R. R.

*Physical Review, The*, v. 108, no. 1, pp. 155-156, October 1, 1957

It is suggested that large cosmic-ray showers can be detected by the electrical signal produced when the ionization of the shower nullifies the electric field of the Earth. The signal should have two components, a very short but small signal due to the motion of free electrons and a slow but possibly large component due to the motion of the ions. The energy of the signal is stored in the Earth's electrical field until it is released by the ionization. An estimate is made of the size and duration of the signals which indicates that they may be detectable, especially in the case of the slow signal which may have a time of rise of the order of a fraction of a second. (PA, v. 61, #1119)

#### 47. TRAPPED ALBEDO THEORY OF THE RADIATION BELT

Singer, S. F.

*Physical Review Letters*, v. 1, no. 5, pp. 181-183, September 1, 1958

Expressions for the equatorial flux and energy spectrum of the radiation belt are derived on the assumptions that protons are injected into the trapping region of the Earth's field by the decay of upward projected neutrons from cosmic-ray stars, that Coulomb scattering leads to leakage from the trap, and that some protons suffer energy loss by collisions. Results are not compatible with data reported by satellites Explorer I and III, but are compatible with preliminary reports from Explorer IV. (PA, v. 62, #1568)

#### 48. CORRELATION OF COSMIC RAY INTENSITY AND SOLAR ACTIVITY

Neher, H. V. and Forbush, S. E.

*Physical Review Letters*, v. 1, no. 1, pp. 173-174, September 1, 1958

It is pointed out that yearly averages of ionization data at Hancayo correlate very well with the average value of the ionization measured at 90,000 ft at Thule, and that there is very good anti-correlation with the yearly average sunspot number. The large ratio of 19:1 for the percentage change near the N geomagnetic pole to that at the equator, is due primarily to the large numbers of low energy primary particles which were present during the solar minimum of 1954, and could get through the Earth's magnetic field at Thule. (PA, v. 62, #2458)

**49. "RADIATION BELT" AND TRAPPED COSMIC RAY ALBEDO**

Singer, S. F.

*Physical Review Letters*, v. 1, no. 5, pp. 171-173, September 1, 1958

It is suggested that cosmic-ray albedo particles, trapped in the Earth's magnetic field, may account for satellite observations of a "radiation belt." The mean lifetime of such particles in the trapping region is deduced, assuming that the rate of leakage equals the total production rate, and an expression is given for the "pitch angle" distribution of the particles at the equator. (PA, v. 62, #1567)

**50. NATURE OF THE CURRENT REDUCTION IN THE PRIMARY COSMIC-RAY INTENSITY**

Pomerantz, M. A., Agarwal, S. P., and Potnis, V. R.

*Physical Review Letters*, v. 1, no. 2, pp. 65-68, July 15, 1958 (See also *Physical Review Letters*, v. 1, no. 3, pp. 107-109, August 1, 1958; v. 1, no. 5, pp. 183-184, September 1, 1958)

**51. SIDEREAL ANISOTROPY OF HIGH ENERGY COSMIC RAYS**

Escobar, I., Nerurkar, N., and Weil, R.

*Planetary and Space Sciences*, v. 1, no. 3, pp. 155-160, August 1959

**52. ORIGIN OF COSMIC RAYS REVEALED IN THE RIGIDITY SPECTRUM OF PRIMARY PARTICLES**

Hayakawa, S. and Koshiba, M.

*Progress of Theoretical Physics*, Japan, v. 21, no. 3, pp. 473-475, March 1959

**53. ACCELERATION OF COSMIC RAYS BY HYDROMAGNETIC WAVE**

Terashima, Y., Kitao, K., and Ogawa, K.

*Progress of Theoretical Physics*, Japan, v. 17, pp. 814-815, June 1957

**54. A REMARK ON HIGH ENERGY PHENOMENA**

Amai, S., Nishida, M., and Murota, T.

*Progress of Theoretical Physics*, Japan, v. 17, pp. 807-812, June 1957

A possible model which discriminates  $\pi$ -N, K-N, and N-N collisions in the cosmic-ray energy region is proposed. The difference in dependence of the multiplicities on the energy of incident particles in  $\pi$ -N, K-N, and N-N collisions is discussed, which is due to the difference of the kinds of the incident particles. Experimental data obtained with nuclear emulsions are analyzed by using the model. If the model is justified, the mean energy of the secondary particles of the  $\pi$ -primary jets must be greater (about twice) than that of the N-primary one, both in nucleon target and nucleus target cases. (NSA, v. 12, #3749)

**55. ON THE ORIGINS OF COSMIC RAYS**

Morrison, P.

*Review of Modern Physics*, v. 29, no. 2, pp. 235-243, April 1957

The main known facts pertinent to the origin of cosmic rays are summed up in this International Congress review paper. It is maintained that the origin of much of the cosmic-ray energy is nuclear in character, and the kind of model than can be built up is discussed. A stirring process would account for the isotropy of the cosmic rays; it could be caused by a chaotic magnetic field in the galaxy. A limited storage is required, and this is met by the radioastronomers' picture of the galaxy not as a flat disk but as a near-sphere. An acceleration process like the one proposed by Fermi may account for the power-law energy spectrum, and it is certain that residual magnetic fields within the solar systems play a major role in the low-energy spectrum. The absence of a high-energy cutoff is, however, hard to understand and astronomical evidence about the Virgo cluster points to the possibility of cosmic-ray energies of  $10^{21}$  ev. Furthermore, astronomical evidence establishes the Crab nebula as a source of a synchrotron type of radiation and it seems that by this means Fermi's natural explanation of the energy spectrum is lost. (PA, v. 61, #486)

**56. MODERN PROBLEMS OF COSMIC RAYS**

Lohrmann, E.

*Raketentechnik und Raumfahrtforschung* (in German), no. 1, pp. 20-21, April 1957

The nature of primaries and the cascade process is discussed.

**57. THE RELATION OF COSMIC RADIO  
EMISSION TO THE ELECTRONIC  
COMPONENT OF COSMIC RAYS**

Tunmer, H.

*Royal Astronomical Society, Monthly Notices of the*,  
v. 2, no. 2, pp. 184–193, June 1959

**58. HIGH-ENERGY COSMIC RAYS**

Rossi, B.

*Scientific American*, v. 201, no. 5, pp. 134–135,  
November 1959

**59. LOGARITHMIC REPRESENTATION OF  
COSMIC-RAY INTENSITY**

Wada, M.

*Scientific Research Institute, Journal of the*, Tokyo,  
v. 51, pp. 201–210, December 1957

To evaluate the quantities which indicate the variational amounts relative to the mean of cosmic-ray intensity, the use of natural logarithms is examined. While a standard unit is required to be determined for the relative intensity when represented by ordinary percentage value, it is not needed for the logarithmic indication. Several advantages due to the use of logarithms are described. (NSA, v. 12, #6021)

**60. PARTICLE ANGULAR DISTRIBUTION  
FUNCTION AT THE CASCADE SHOWER  
MAXIMUM**

Ivanenko, I. P.

*Soviet Physics-JETP*, v. 6, pp. 637–639, March 1958

The distribution function of particles with respect to energy and angle was calculated at cascade shower maximum without assuming small deflection angles. The scattering was not considered to be multiple. Equations determining the energy and angular distribution function of electrons are derived. (NSA, v. 12, #10,720)

**61. A COMPARISON OF THE FERMI-LANDAU  
THEORY WITH SOME EXPERIMENTAL  
DATA ON COSMIC RAYS**

Guzhavina, O. A., Gizhavin, V. V., and Zatsepin, G. T.  
*Soviet Physics-JETP*, v. 4, pp. 690–700, June 1957

The energy spectra of the secondary particles originating in nuclear collisions of high-energy particles ( $10^{12}$  to  $10^{18}$  ev) have been calculated on the basis of the theory of L. D. Landau. A calculation of the altitude dependence of the radioactive particles in the atmosphere, as well as of the number of high-energy  $\mu$ -mesons at sea level, has been carried out on the basis of the spectra obtained. The results of the calculations are compared with experimental data. (NSA, v. 12, #2993)

**62. MOMENTUM SPECTRUM OF COSMIC  
RADIATION**

Alfvén, H.

*Tellus*, v. 11, no. 1, pp. 106–115, February 1959

If in a variable magnetic field charged high-energy particles are injected at a certain point, they are accelerated but at the same time they diffuse outward from the point of injection. Near the point of injection the density in a volume element of six-dimensional phase-space is increased by the acceleration process but decreased by the diffusion, and the momentum spectrum is obtained from the stationary state when these two effects are equal. The theory gives two expressions for the power spectrum, in which the value of the exponent depends in a very insensitive way on the rate of acceleration and the rate of diffusion. The spectrum depends on the distance from the source of injection and the average energy density is orders of magnitude smaller than the density near the source of injection. The theory is in agreement with the "local" theory of cosmic radiation, but it is difficult to reconcile it with galactic or extra-galactic theories. (PA, v. 61, #7137)

**63. THE MAGNETIC STORM EFFECTS AND  
THE INTERPLANETARY ELECTROMAGNETIC  
STATE**

Venkatesan, D.

*Tellus*, v. 9, no. 2, 209–219, May 1957

The electric field of the beam of rarefied, ionized gas ejected from the Sun was invoked by Alfvén in connection with geomagnetic storms and aurorae. An attempt is made to study the effects of this electric field on cosmic rays. From a study of the ionization chamber records published by Carnegie Institution for the years 1945 and 1946, it appears that the deceleration in the electric field

seems to be the most important among the type of effect expected in cosmic rays. The study reveals that it is possible to use the same mechanism to explain both the 27-day variation and the Forbush decreases. The maximum (or minimum) of cosmic-ray intensity precedes the maximum (or minimum) of  $Kp$  by 4–6 days. The direction of the electric field of the beam is also discussed. (PA, v. 61, #8101)

**64. FOCUSING OF PARAXIAL RAYS IN A MAGNETIC DIPOLE FIELD**

Åström, E.

*Tellus*, v. 8, no. 2, pp. 254–259, May 1956

A magnetic field of axial symmetry has a focusing effect for paraxial orbits. The field of the Earth is of this type and it is shown that, if the cosmic rays consist of protons, a bundle of orbits parallel at infinite distance is focused on the surface of the Earth if the energy is about 10 Bev. The co-latitude of the bundle at infinite distance is about 2.2 times the co-latitude of the focal point. The asymptote to the orbits is about 22 deg further to the east than the focal point. There is also an infinite series of lower energies exhibiting focusing properties. The calculations refer to paraxial orbits, but a comparison with terrella measurements shows that the focal energy and the above relation between the co-latitudes are appropriate down to about 50° latitude. (PA, v. 61, #7156)

**65. UBER DIE KOSMISCHE STRAHLUNG (ABOUT COSMIC RADIATION)**

Stubell, V. W.

*Weltraumfahrt*, v. 10, no. 2, pp. 71–72, June 1959

**66. ON THE PENETRATING COMPONENT OF EXTENSIVE ATMOSPHERE SHOWERS**

Kazarov, R. E. and Lyudvigov, R. B.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 35, pp. 1310–1311, November 1958

**67. ACCELERATION OF COSMIC RAYS IN A FLUCTUATING MAGNETIC FIELD**

Byakov, V. M. and Avalov, R. G.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 35, no. 5(11), pp. 1181–1184, 1958

A mechanism of acceleration of cosmic rays is considered in a fluctuating magnetic field of the Galaxy or the

atmospheres of some types of stars. During the motion of cosmic particles in these fields the “diffusion” in energy, as well as systematic acceleration, takes place. Computations indicate that the mechanism considered here may be more efficient than the Fermi acceleration mechanism. (PA, v. 62, #2470)

**68. ON A POSSIBLE MODE OF DEVELOPMENT OF EXTENSIVE ATMOSPHERIC SHOWERS**

Grigorov, N. L. and Shestoporov, V. Ya.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 34, no. 6, pp. 1539–1547, 1958

The development of extensive atmospheric showers is examined under the assumption that the fraction of energy lost in the interaction of ultra-high-energy particles with light nuclei strongly fluctuates. It is shown that the main features of extensive air showers can be explained without making recourse to the hypothesis that the nuclear component plays an important role in development of the showers in the depth of the atmosphere. (PA, v. 62, #379)

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**69. INVESTIGATION OF NUCLEAR DISINTEGRATIONS PRODUCED BY THE CHARGED COMPONENT OF COSMIC RADIATION**

Asatiani, T. L. and Khrimyan, G. V.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 33, no. 3(9), pp. 561–567, 1957

The momentum spectrum of negative  $\pi$ -mesons from stars created by charged cosmic rays of  $\sim 30$  Bev energy has been obtained. The power exponent of the spectrum is  $\gamma = 1.46 \pm 0.2$ . The ratio of positive to negative  $\pi$  mesons is  $N_{\pi^+}/N_{\pi^-} = 1.67^{+0.81}_{-0.53}$  and the number of protons produced by particles possessing a momentum  $p \geq 10^9$  ev/c is  $\sim 30$  percent. (PA, v. 61, #1763)

**70. PROBABILITY OF CHARGE EXCHANGE IN NUCLEONS WITH ENERGIES  $3 \times 10^9 - 10^{10}$  ev IN INTERACTION WITH AIR**

Vorob'ev, V. A.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 33, no. 1(7), pp. 264–265, 1957

The probability of charge exchange is evaluated from experimental results on the proton current at various heights and is found to be 0.2 to 0.3. (PA, v. 61, #1752)



## B. Instrumentation

### Reports

#### 71. ABSOLUTE MEASUREMENTS WITH A 4 $\pi$ -COUNTER

Martinsson, K.

March 1958 (Revised June 1958)

Aktiebolaget-Atomenergi, Stockholm

AE-5 (25 pp.)

Measurements on standardized  $\beta$  emitters were made in a 4- $\pi$  proportional flow counter. The counter efficiency was found to be near 100 percent. Absorption curves were determined with plastic foils and aluminum. A comparison is made between the self-absorption arising in different methods of source preparation which include precipitates and the use of wetting agents. The most reliable results were obtained with sources on aluminium foils, where the foil absorption was calculated from the absorption curves and the self-absorption is supposed to be negligible for isotopes with end point energy above 0.5 Mev. The  $\beta$ -emitters studied have energies ranging from 1.71 Mev ( $P^{32}$ ) to 0.167 Mev ( $S^{35}$ ). (NSA, v. 13, #12,580)

#### 72. GEIGER-MULLER TYPE COUNTER TUBE

April 22, 1959

Atomic Energy of Canada, Ltd.

British Patent 812,183

A halogen-quenched Geiger-Mueller tube design is offered which is sensitive in a high range and a low range and also has a variable sensitivity ratio for  $\beta$  and,  $\gamma$  radiation. Six tube configurations are described in which either the central anode or the outer cathode is conical or so shaped that the space between anode and cathode is varied. This variation permits operation as two counters without the disadvantages commonly incurred in parallel counter operation. (NSA, v. 13, #11,815)

#### 73. HELIUM-3 FAST NEUTRON SPECTROMETER, I. THE PROPORTIONAL COUNTER

Batchelor, R. and Aves, R.

October 13, 1954

Atomic Energy Research Establishment,  
Great Britain

AERE N/R 1499, HD 2896 (OS)

(ASTIA AD-200,831)

A proportional counter filled with helium-3, and suitable for use as a fast neutron spectrometer is described. The performance, in terms of resolution, linearity and wall effect, is discussed. The resolution obtained with thermal neutrons is  $(3.15 \pm 0.15)$  percent. Suggestions for future improvements are added.

#### 74. PERFORMANCE OF A SIX POSITION GRIDDED IONIZATION CHAMBER FOR ALPHA ENERGY MEASUREMENTS

Glover, K. M.

November 1956

Atomic Energy Research Establishment,  
Great Britain

AERE C/R 2091, HD-2462 (HU)

(ASTIA AD-138,666)

The preliminary measurements and results obtained using a gridded ionization chamber built to a Chalk River design are reported. The high geometry (50 percent) makes it suitable for analyzing low-activity samples or samples whose specific activity is low and the total activity is thus limited by source thickness. The six-position turntable incorporated in this instrument enables a calibration and background to be done under conditions identical with those used for the sample under investigation.

#### 75. SPECIAL LOW LEVEL COUNTERS

Geiss, J., Gfeller, C., et al.

A/Conference 15/P/236

The anticoincidence volume and the counting volume are separated by a foil of adapted thickness or, in the case of very short-range radiation, by thin wires. Three different types of counters were constructed based on this principle: (1) a 1½ liter counter for gas samples of low specific activity (natural  $C^{14}$ , tritium) with a background of 0.8 counts per minute; (2) a 5 cm<sup>3</sup> counter for small gas samples of low total activity (spallation products in meteorites) with a background of 0.1 counts per minute; and (3) a 4 $\pi$  counter surrounded by an anticoincidence ring which is separated from the two counting volumes by a thin foil and a background depending on the foil thickness (lower than 0.5 counts per minute). A full description of the performance of the counters is given. (NSA, v. 13, #6709)

**76. LAWRENCE RADIATION LABORATORY  
COUNTING HANDBOOK**

January 1, 1959  
California, University of,  
Lawrence Radiation Lab., Livermore  
UCRL-3307 (Revised) (224 pp.)  
W-7495-eng-48

A large number of nuclear counting devices are included with detailed descriptions and operating specifications. The listings are as follows: amplifiers; cables and coaxial components; coincidence systems and discriminators; components; definitions and standards; engineering performance and applications; oscilloscopes and monitoring; photomultipliers and scintillators; scalers and readout equipment; and wave-form generators and analyzers. (NSA, v. 13, #16,159)

**77. RESEARCH AND DEVELOPMENT IN  
CONNECTION WITH HIGH ALTITUDE  
CLOUD CHAMBER STUDY OF COSMIC RAY  
NUCLEAR INTERACTIONS**

Weaver, A. B.  
January 1, 1956–December 31, 1958  
Colorado, University of, Boulder  
Final Report NP-7196  
DA-5B99-01-004, DA 23-ORD-956

The design and construction of cloud chambers for high-altitude cosmic-ray studies are described. The arrangement includes 3 stacked chambers and associated counters, circuits, oscillographs, and cameras. (NSA, v. 13, #5677)

**78. A RECORDING IONIZATION CHAMBER  
INSTRUMENT**

Cunningham, J. R. and Wilson, R.  
June 1958  
Defense Research Chemical Labs., Canada  
Report 261  
(ASTIA AD-201,265)

A sensitive recording ionization chamber with three ranges, 0 to 1, 0 to 10, and 0 to 100 mr/hr, is described. The dc amplifier uses 100 percent negative feedback to achieve good stability and linearity. The high sensitivity is achieved partly through use of a large volume (5.5

litres) cylindrical chamber. The presence of a dip in the polar response curve in the direction along the axis of the chamber is discussed.

**79. SHOWER DETECTORS**

Hofstadter, R.  
January 1959  
European Organization for Nuclear Research,  
Geneva  
CERN-59-4

A high energy sodium iodide scintillation counter is described. After passing through the sodium iodide crystal, the incoming radiation passes through a lucite coupling lens and enters the photomultiplier. (NSA, v. 13, #8839)

**80. A SENSITIVE  $\text{BF}_3$  IONIZATION CHAMBER**

Haake, E. V.  
April 4, 1951  
Fairchild Engine and Airplane Corp.,  
Oak Ridge, Tenn.  
Report NEPA-1742  
(ASTIA AD-149,840)

**81. COSMIC RAY INSTRUMENTATION IN THE  
FIRST U. S. SATELLITE**

Ludwig, G. H.  
March, 1958  
Iowa, State University of, Physics Dept., Iowa City  
SUI 58-4  
Project U.S./IGY 32.1

A detailed description is given of the cosmic ray instrumentation which was flown in the first U. S. satellite, *Explorer I*.

**82. EXPLORER SATELLITE ELECTRONICS**

Victor, W. K., Richter, H. L., and Eyraud, J. P.  
January 29, 1960  
Jet Propulsion Laboratory, California Institute of  
Technology, Pasadena  
TR 34-12

A discussion is presented of the design restrictions and the philosophy which enabled the *Explorer* satellites to be the first during the IGY to reveal the presence of a belt

of intense cosmic radiation encircling the Earth's equator. An indication of the amount and momentum of cosmic dust in the solar system was also obtained. Methods used to obtain reliability in the transducing and communications system are described, together with interpretations of space-environment information as deduced from the narrow-band telemetry.

**83. FINAL REPORT ON PROJECT ESP-27 TO THE WORKING GROUP ON INTERNAL INSTRUMENTATION OF THE TECHNICAL PANEL ON THE EARTH SATELLITE PROGRAM**

Butler, C. T.

May 19, 1959

Jet Propulsion Laboratory, California Institute of Technology, Pasadena

Publication 163

The project consists of a cosmic ray experiment and a photometer experiment.

**84. PROPOSAL FOR MODIFICATION OF THE STATE UNIVERSITY OF IOWA COSMIC RAY EXPERIMENT FOR THE JUPITER C VEHICLE**  
December 2, 1957

Jet Propulsion Laboratory, California Institute of Technology, Pasadena

Publication 115

The proposed experiments for the launching of two Earth satellites by the *Jupiter C* re-entry test vehicle are outlined. The first experiment has the objective of gathering environmental data, flight-testing major items of hardware, and making certain scientific measurements. The second experiment, a modified SUI cosmic ray experiment, has the objective of ascertaining primary cosmic ray intensity; description and block diagrams are given for the instrumentation.

**85. LIQUID SCINTILLATOR AND REFLECTIVE-COATING STUDY**

Arakengy, A. and Kloepper, R. M.

September 1957

Los Alamos Scientific Lab., New Mexico

W7405-eng-36, LAMS-2154

(ASTIA AD-154,523)

This report is a study of the comparative responses of some scintillators in tanks of various reflective coatings

to gamma rays from  $\text{Cs}^{137}$  and  $\text{Co}^{60}$  sources. In order of decreasing quality, the scintillators tested, all of which contained p-terphenyl, were toluene-POPOP, xylene- $\alpha$ -NOP, polystyrene- $\alpha$ -NPO, and triethylbenzene-POPOP. The reflective coatings tested were: Plasite,  $\alpha$ -alumina in sodium silicate, and titanium dioxide in Zapon Aquinate Lacquer.

**86. THE SMALL-VOLUME INTERNAL-SAMPLE LIQUID SCINTILLATION COUNTER. INSTRUMENTATION, PERFORMANCE CHARACTERISTICS AND CAPABILITIES**

Hayes, F. N. and Ott, D. G.

January 1957

W7405-eng-36, LA-2095 (26 ref.)

(ASTIA AD-142,821)

(Available from Office of Technical Services, Washington, D.C.)

Fundamental considerations and practical data are presented for the small-volume internal-sample liquid scintillation counter. Steps in the complex transformation from disintegration of a radioactive nuclide to emergence of a count on the scaler are explored for their physical significance. Characteristic data are given for  $\text{H}^3$ ,  $\text{C}^{14}$ , and background counting with a representative coincidence instrument. A comprehensive guide to the conversion from assay sample to counting solution is offered.

**87. THE MOMENTUM DISTRIBUTION OF THE SOLAR COSMIC RADIATION IN THE DECREASING PHASE OF THE SUDDEN RADIATION INCREASE ON 23 FEBRUARY 1956**

Pfotzer, G.

Max Planck-Institute für Stratosphärenphysik, Mitteilungen (in German), no. 7, 1955 (20 pp.)

On the occasion of the above event the European stations registered at first a direct radiation and later a radiation which had been deflected by interplanetary fields; all other stations registered the indirect radiation only. It is difficult to determine a momentum distribution from the latitude effect of the initial phase. However, in the decreasing phase a uniform time law is observed from which is concluded that in this phase largely isotropic indirect radiation only has been registered. From this a momentum distribution has been derived which can be represented by  $f(p)dp = (p/p_0)^{-6 \pm 0.5}$ . (PA, v. 62, #2472)

**88. THE FALLING OFF OF THE SOLAR COSMIC RADIATION AFTER THE SUDDEN INCREASE ON 23 FEBRUARY 1956 AND THE GEOMAGNETIC IMPACT CONDITIONS**

Ehmert, A. and Pfozter, G.

Max Planck-Institute für Stratosphärenphysik,  
Mitteilungen (in German), no. 6, 1956 (14 pp.)

On the strength of an analysis of neutron registrations of various stations it is concluded that, shortly after the sudden increase, radiation arrives only from a direction very near the Sun. The European stations between 35°W and 10°E seem to be in a favorable impact zone. The particles have been deflected on their path by about 25°. The mean delay of the beginning of the increase increases strongly from the equator towards the pole. The decrease is in accordance with a uniform hyperbola law for all stations implying that the latitude effect of this phase is constant in time. The indirect radiation should therefore have become isotropic before its entry into the magnetic field of the Earth. Also, the uniform decrease favors the explanation that the emission of the c.r. particles did not last longer than the optically visible flare. (PA, v. 62, #2471)

**89. PHOTOGRAPHY OF COSMIC RAY TRACKS WITH A CASCADE LUMINESCENT CHAMBER**

Jones, L. W. and Perl, M. L.

December 24, 1958

Michigan, University of, Ann Arbor

Technical Report 1, Nonr-1224(23)-NR-022-274,  
DA-36-039-SC-52654

The tracks of minimum ionizing particles were photographed in a luminescent chamber for what is believed to be the first time. A cascade luminescent chamber made up of three image tubes coupled with refractive optics were used to photograph tracks of cosmic ray  $\mu$  mesons in a sodium iodide crystal. The apparatus is described, together with details of measurements on image tube characteristics and the nature of background. The same type of apparatus is applicable to other problems where very weak light signals (several thousand photons total) must be photographed. (NSA, v. 13, #4810)

**90. RESPONSE CURVES FOR USNRDL 4-PI IONIZATION CHAMBER**

Miller, C. F.

May 17, 1959

Naval Radiological Defense Lab.,  
San Francisco, Calif.

USNDRL TR-155 (74 pp.)

(ASTIA AD-150,110)

**91. A LARGE SCINTILLATOR FOR OBSERVATION OF COSMIC RAYS**

Green, J. R.

July 22, 1957

New Mexico, University of, Albuquerque

AF 49(638)34, AFOSR TN-57-433

(ASTIA AD-136,423)

A liquid scintillator having an area of 5 sq m was developed for observation of cosmic rays. Details of construction and also of certain of the electronic circuits are given.

**92. SCINTILLATION RESPONSE OF LiI(EU) CRYSTALS TO MONOENERGETIC FAST NEUTRONS**

Murray, R. B. and Schenck, J.

May 11, 1956

Oak Ridge National Lab., Tenn.

W7405-eng-26, ORNL-CF-56-5-76

(ASTIA AD-143,868)

The scintillation response of LiI(Eu) crystals to monoenergetic fast neutrons has been investigated in the course of a study directed toward the development of a more versatile and efficient fast-neutron spectrometer. The scintillation response has been determined as a function of neutron energy (in the range of 0.63 to 14.9 Mev), Eu concentration, Li isotope concentration, and crystal temperature. The pulse height spectra of those crystals containing Li<sup>6</sup> demonstrate a peak from the fast neutron induced Li<sup>6</sup>(n,  $\alpha$ )t reaction. At room temperature the peak from fast neutrons of energies less than 6 Mev is broad and roughly rectangular in shape. A substantial improvement in the shape and resolution of the fast-neutron peak is found, however, on cooling the crystals to about -140°C.

**93. A STUDY OF THE HODOSCOPE CHAMBER**

Fukui, S. and Miyamoto, S.

December 14, 1957

Osaka University, Japan

INS-TCA-10 (16 pp.)

Development of a radiation detection instrument which consists of parallel metal plates between which a number of glass tubes are inserted is described. Each tube is filled with a mixture of rare gases. When a strong electric current is applied to the plates immediately after the passage of a charged particle, the tubes of the trajectory of the particle are lighted. A schematic sketch of the chamber and a block diagram of the trigger circuit are included. Applications in the study of extensive cosmic showers are discussed. (NSA, v. 12, #6067)

**94. A STUDY OF THE HODOSCOPE CHAMBER.**

**II. A PRELIMINARY STUDY OF A NEW  
DEVICE OF A PARTICLE DETECTOR**

Fukui, S. and Miyamoto, S.

April 10, 1954

Osaka University, Japan

INS-TCA-11 (in Japanese with English abstract)

Discharges occurring in such tubes as Conversi counters were investigated with respect to their dependence on the intensity of the pulse field, on the time delay of the applied pulse, and on the wave form of the pulse. Moreover, a preliminary test for a new detector suggested in a previous paper (INS-TCA-10) was conducted by using tubes of 0.2 cm diameter filled with the mixture (Ne + 0.1% Ar) at 50 cm Hg. Diffusion of discharges from a particle trajectory was found to depend mainly on the time width of the applied high voltage pulse. In order to develop discharges corresponding correctly with the trajectory, the time width of the pulse must be made shorter than  $10^{-7}$  sec. Photographs of tracks of cosmic ray particles obtained with this instrument are shown. (NSA, v. 12, #10,805)

**95. QUARTERLY PROGRESS REPORT [FOR]**

**JUNE 1, 1958–AUGUST 31, 1958**

Reynolds, G. T.

Princeton University, Palmer Physical Lab., and  
Naval Ordnance Lab., N.J.

NP-7377 (61 pp.) Nonr-1858-(06)

Work on the development of filament scintillators is described. Under this development program, image tube gain measurements, light pipe coupling of image tubes, and a high-voltage pulser for image intensifiers are discussed. Preliminary results on a double cloud chamber investigation of 500-M<sub>e</sub> particles and counter results are

given. The lifetime analysis of the  $\Lambda^0$  and  $\theta^0$  particles observed to decay in the 36-in. multiplate cloud chamber was completed, and the hyperons due to the interactions of neutral K mesons of negative strangeness were analyzed. (NSA, v. 13, #11,964)

**96. HEAVY PRIMARY COSMIC RAYS**

Young, O. B.

October 1959

Southern Illinois University, Carbondale,  
DA-23-072-ORD-770, DA Project 599-01-004  
ORD Corps Project TB2-0001,  
Cosmic Ray Research (91 pp.)

Techniques for processing 600-micron thick electron sensitive nuclear emulsions are described and suggestions are given for beginners in emulsion plate scanning adapted to heavy nuclear projects. Since the chief way to identify heavy nuclei which produce tracks in emulsions involves delta rays, considerable attention is devoted to a procedure which will give consistent results. The charge identification of heavy nuclei by use of emulsions of different sensitivities is also discussed. Data regarding heavy primary cosmic rays at geomagnetic latitude of 41°N near the geomagnetic equator, and at g.m. latitude of 55°N are presented. The relationship between ground-level neutrons and high altitude heavy primary cosmic rays is discussed.

**97. FEASIBILITY OF A GRAPHITE-CARBON  
DIOXIDE IONIZATION CHAMBER TO  
MEASURE CARBON DOSE AT HIGH DOSE  
RATES**

Hickmott, R. L.

December 1957

Wright Air Development Center, Materials Lab.,  
Wright-Patterson AFB, Ohio  
WADC TN 57-335  
(ASTIA AD-142,249)

A detailed discussion of a graphite-CO<sub>2</sub> ion chamber is presented. The terminology used is explained, and the reactions which occur in the chamber are discussed qualitatively in the first portion of the report. The Bragg-Gray theory is also discussed. Besides neutron response, two other effects (volume recombination and electron multiplication) which may limit the use of the ion chamber were studied. The ability of these effects to cancel each other is explained. Mention is also made of the effect of

space charge on the ion chamber and the problem of the insulating materials for use in an ion chamber to be exposed to large doses of radiation.

### Books

#### 98. AN INTRODUCTION TO RADIATION COUNTERS AND DETECTORS

Washtell, C. C. H.

George Newness, Ltd., London, 1956 (123 pp.)

Information is presented on the applications, design, and operating characteristics of radiation detectors and measurement techniques. A review is given of the historical background of radioactivity and atomic structure. Chapters are devoted to discussions on Geiger-Mueller tubes and other types of detectors based on ion collection and dosimetry. (NSA, v. 13, #7723)

### Periodicals

#### 99. UTILIZATION OF SCINTILLATION COUNTERS FOR THE DETECTION OF FAST NEUTRONS

Schachter, L. and Totia, H.

*Academia republicii populare Romine, Institutul de fizica atomica si Institutul fizica, Studii si cercetari de fizica* (in Rumanian), v. 9, pp. 497-504, 1958

The possibility of using scintillation counters of the Chang and Rosenblum type for the detection of fast neutrons by the recoil nuclei method was studied. Counters filled with air, nitrogen, or hydrogen at atmospheric pressure were constructed. A graphic method was developed to determine the resistance of optimum charge of the counter. The counters have good plateaus and a negligible background and are insensitive to gamma rays. The nitrogen-filled counters are sensitive to thermal neutrons because of the  $N^{14}(n,p)C^{14}$  reaction. (NSA, v. 13, #12,601)

#### 100. DETERMINATION OF THE FLUX OF THE PRIMARY COSMIC PARTICLES AT 31°N LATITUDE

Alekseeva, K. I. and Briker, S. I., et al.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 115, pp. 71-74, July 1, 1957

The intensity of the hard component in the stratosphere was measured during the determination of the cross section for the inelastic interaction of cosmic ray particles

with carbon and hydrogen nuclei. The measurements permitted the determination of the flux of the primary particles at the atmosphere boundary. Descriptions are given of the instruments used for the measurements of the inelastic interaction and of the results obtained in measuring the intensity of the hard component; however, the results of the cross section measurements will be published later. The absorption range of the charged particles of the shower-forming component in the stratosphere at the 31°N latitude was found to be 150 to 170 g/cm<sup>2</sup>. (NSA, v. 12, #338)

#### 101. SELF-CONTAINED PREAMPLIFIERS FOR PROPORTIONAL COUNTERS

Bradley, G. E.

*American Journal of Physics*, v. 27, p. 365, May 1959

A self-contained preamplifier for a proportional counter is described. The preamplifier is used in conjunction with a scaler. The circuit is transistorized and may be contained in a small chassis attached to the counter. Only one cable to the scaler is required. (NSA, v. 13, #12,605)

#### 102. THE OPTICS OF COSMIC RAY TELESCOPES

Brunberg, E. A.

*Arkiv för Fysik*, v. 14, Paper 16, pp. 195-262, 1958

The directional properties of cosmic ray telescopes are analyzed with regard to both geomagnetic deflection of the primary particles and to the spread in the atmosphere of the secondaries. The concepts "image of a cosmic ray source" and "polar diagram of a telescope outside the Earth's magnetic field" are introduced. Image of a cosmic ray source is defined as the intensity variation recorded by a telescope during one day. The polar diagram represents the sensitivity of a telescope for different angular positions of a cosmic ray source element on the celestial sphere. A few examples of calculating polar diagrams are given. The resolving power of cosmic ray telescopes is discussed. (PA, v. 62, #1565)

#### 103. $\alpha$ -PARTICLE INDUCED SCINTILLATIONS IN HIGH-PRESSURE HELIUM

Baldwin, S. A., Gavrilovskiy, V. V., and Chukreyev, F. Ye.

*Atomnaya Energiya*, v. 3, no. 10, pp. 331-334, 1957

The scintillations were investigated in an attempt to find a sufficiently effective method of establishing the

polarization degree of a neutron beam of 2 to 20 Mev. This method is based upon the registration of the coincidences between the scattered neutrons and the recoil nuclei in the gas scintillation chamber filled with pure helium at 10 atm. pressure. The dependence of the counting velocity upon pressure of the various gas mixtures (pure He, He + Xe, He + Ar, He + O<sub>2</sub>, He + N<sub>2</sub>) was measured, and the corresponding curves are shown. (NSA, v. 12, #9320)

**104. A LARGE-AREA LIQUID SCINTILLATION COUNTER AND SOME MEASUREMENTS ON HIGH-ENERGY COSMIC-RAY PARTICLES**

Millar, C. H., Hincks, E. P., and Hanna, G. C.  
*Canadian Journal of Physics*, v. 36, pp. 54-72,  
January 1958

A liquid scintillation counter is described which consists of a 29¾ in. by 29¾ in. by 2 in. Plexiglas tank of terphenyl  $\alpha$ -naphthylphenyloxazole ( $\alpha$ NPO) in triethylbenzene. The tank is surrounded by MgO powder and viewed by a total of eight RCA Type 5819 photomultiplier tubes along two opposite edges. For normally incident fast  $\mu$  mesons a peaked pulse height distribution is observed, 20.5 percent in width at half-maximum for the central area of the counter, broadening to 25 to 30 percent at the perimeter, and estimated to be 25 percent over-all. When the Landau distribution in energy loss (width 18 percent at half-maximum) and the geometric spread are taken into account, a counter resolution function 8 percent in width at half-maximum is obtained for the central area of the counter, or 18 percent for the counter as a whole. The most probable pulse height for 0.30 Bev  $\mu$ -mesons is  $1.6 \pm 0.5$  percent higher than for 2.2 Bev  $\mu$ -mesons, in close agreement with the Bethe-Bloch theory as extended by Symon and with a density correction calculated by the method of Sternheimer. Pulse heights from protons in the region 0.3 to 0.8 Bev vary directly with the theoretically computed energy loss in the counter. Peak position and resolution are unchanged by a flux of 12 mr/hr of thorium  $\gamma$  rays. (NSA, v. 12, #5427)

**105. SCINTILLATION DETECTOR FOR SLOW NEUTRONS**

Vousek, M.  
*Czechoslovak Journal of Physics*, v. 7, pp. 396-407,  
1957

A mixture of ZnS (Ag) and B<sub>2</sub>O<sub>3</sub> was investigated with an aim toward using it for detection of thermal and resonant neutrons. The ratio of the ZnS(Ag): B ranging from 8:1 to 12:1 is optimum from the point of view of the efficiency with respect to neutrons, and of the form of the integral spectrum. The best thickness of the layer of the mixture is 0.75 to 1.0 mm. For these optimum values, the efficiency of the mixture with respect to neutrons is 25 percent at a low background of gamma rays. At a strong background of gamma rays, it is possible to reduce the background to 10<sup>-7</sup> percent with the aid of a discriminator, and the efficiency for neutrons remains not less than 5 percent. (NSA, v. 13, #11,797)

**106. DIRECT COUPLED SINGLE CHANNEL PULSE HEIGHT ANALYZER**

Cottini, C., Gatti, E., and Principi, P.  
*Energia nucleare*, Milan, v. 6, pp. 73-76,  
January 1959

A lengthener circuit provides a flat top to the input pulses to which two standard step pulses are subsequently added. The height of the second step determines the channel width. The only transitions of an output Schmitt discriminator selected are those which correspond to a triggering caused by the leading edge of the second step superposed on the input pulses. (NSA, v. 13, #11,798)

**107. THE IONIZATION CHAMBER AS AN INSTRUMENT FOR THE CONTINUOUS RECORDING OF COSMIC RADIATION**

Messerschmidt, W.  
*Experimentelle Technik der Physik* (in German),  
v. 6, no. 4, pp. 145-156, 1958

Four chambers have been working satisfactorily at Halle since 1956 without interruption. Their volume is 20 litres containing nitrogen at 22 atm. A compensation method is employed. The residual current in the chamber is  $1.7 \times 10^{-14}$  A. In the case of the measurements carried out during the International Geophysical Year the fluctuations of the chambers were less than  $\pm 0.3$  percent per hour. (PA, v. 62, #2549)

**108. PROPERTIES OF MASS-PRODUCED SCINTILLATION MULTIPLIERS**

Gorlich, P., Krohs, A., Pohl, H. J., and Schmidt, L.

*Experimentelle Technik der Physik* (in German),  
v. 5, no. 1, pp. 1-13, 1957

The characteristics of the Zeiss M12FS scintillation counter tube are described in detail, special attention being given to the variation in over-all sensitivity over the cathode surface. The resolving time is considerably better than  $10^{-7}$  sec. (PA, v. 61, #256)

**109. ABSORPTION MEASUREMENTS OF COSMIC RADIATION WITH A SCINTILLATION COUNTER**

Burckhardt, C.

*Helvetica Physica Acta* (in German), v. 29, no. 5-6, pp. 533-544, 1956

Cosmic ray events were recorded in a scintillation spectrometer fitted with a cylindrical crystal of NaI(Tl) 37 mm in diameter and 22 mm in height. Pulses were recorded in a multi-channel pulse analyzer previously described. A liquid scintillation counter shielding the crystal permitted the distinguishing of events produced by charge and neutral primaries. Horizontally placed sheets of cast iron were used as absorbers. The apparatus was raised above ground to reduce albedo. The pulse size distribution in the unshielded crystal is given for events causing 5 to 500 Mev pulses in the crystal. Absorption curves were obtained for events corresponding to energy releases exceeding 5, 10, 20, 40, and 80 Mev in the crystal. Energy releases  $> 80$  Mev are ascribed to stars in the crystal. Both charged and neutrally produced stars show marked transition effects with maxima at  $25 \text{ g/cm}^2$  of Fe and suggest second maxima at about  $100 \text{ g/cm}^2$  similar to those observed by Schopper et al. in emulsion and scintillators. (PA, v. 62, #8271)

**110. UN APPAREIL POUR LES MESURES DE COINCIDENCES A GRAND POUVOIR DE RESOLUTION (HIGH RESOLUTION APPARATUS FOR COINCIDENCE MEASUREMENTS)**

Bradt, H. and Scherrer, P.

(CEA-tr-A-408), Translated into French from *Helvetica Physica Acta*, v. 16, pp. 251-258, 1949 (14 pp.)

A coincidence amplifier with a maximum resolution of  $0.8 \times 10^{-7}$  sec is described. The coincidence and anti-coincidence circuits are given. The limitation of the useful resolution by the time lag is determined. (NSA, v. 13, #16,162)

**111. ZENITH ANGLE RESPONSE OF A VERTICAL MESON TELESCOPE**

Kane, R. P. and Rao, U. R.

*Indian Academy of Science, Proceedings of the, Section A*, v. 47, no. 1, pp. 30-40, January 1958

Expressions were obtained for the geometrical sensitivity as a function of the zenith angle of a telescope comprising counter trays of rectangular dimensions. The radiation sensitivity and cumulative sensitivity were also calculated, assuming a zenith angle attenuation of the form  $I_0 = I_0 \cos^2 \theta$  for the cosmic ray intensity. (PA, v. 61, #6012)

**112. SPACE-CHARGE EFFECTS IN A PROPORTIONAL COUNTER**

Venkatasubramanian, V. S.

*Indian Institute of Science, Journal of the, Section A*, v. 39, no. 2, pp. 125-128, April 1957

From the known characteristics of the space charge, an expression for the gas multiplication in a proportional counter is derived as a function of the primary ionization. The results are applied to the case of  $\alpha$ - and  $\beta$ -particle pulses. (PA, v. 62, #491)

**113. SCIENTIFIC OBJECTIVES OF THE ABLE-3 PROGRAM**

*IRE Transactions on Military Electronics*, v. MIL-3, no. 4, pp. 129-143, October 1959

The goals of the Able-3 program in placing a scientific observatory in a large elliptic orbit are to provide scientific data concerning the Earth.

**114. INSTRUMENTATION AT THE ETH**

Maeder, D. G.

*IRE Transactions on Nuclear Science*, v. NS-5, pp. 214-221, December 1958

After a brief outline of applications of scintillation counters to nuclear studies at ETH (Eidgenoessische Technische Hochschule), some topics in electronic circuit developments are selected for a more detailed discussion. A linear overload-protected amplifier is described in which pulse shape parameters can be adjusted independently. In the linear amplifier double rectangular pulse shaping is produced by a ferrite core delay line of novel design. Higher order phase corrections are obtained by



a combination of inductive and capacitive couplings. Fast timing signals are derived from slow scintillation pulses using a nonlinear amplifier circuit. Amplitude-dependent time jitter is reduced by a special design of interstage couplings. Requirements to be met by pulse stretchers are listed, and a corresponding circuit diagram is presented. Ultrasonic delay lines can be used for the storage of channel counts in a pulse spectrometer. A new type of magnetostrictive transducer has been developed in order to improve the reliability of such a memory. Increased signal amplitude is obtained along with a suppression of unwanted reflections. Straightforward decimal coding, as used in ultrasonic storage and in electrostatic storage type pulse spectrometers, is explained briefly. Automatic data recording from the CRT display of the ultrasonic memory spectrometer is demonstrated. The electrostatic memory spectrometer is demonstrated. The electrostatic memory spectrometer is presently operative with four decimals on each of 32 columns in the storage tube. A possible way of using a pulse spectrometer for automatic computing in the analysis of complex scintillation spectra is suggested. (NSA, v. 13, #3779)

#### 115. PRESENT STATUS OF SCINTILLATION COUNTER DEVELOPMENT IN FRANCE

Labeyrie, J.

*IRE Transactions on Nuclear Science*, v. NS-5, pp. 212-214, December 1958

Some properties of different types of photomultipliers in commercial use in France, such as background linearity at high currents, transit time fluctuations, and stability for  $\beta$  counting, are discussed. In addition, some properties of different types of scintillators in commercial use or under development are presented. (NSA, v. 13, #3778)

#### 116. APPLICATIONS OF LIQUID SCINTILLATION COUNTERS

Hayes, F. N.

*IRE Transactions on Nuclear Science*, v. NS-5, pp. 166-170, December 1958

A survey of the most notable applications is presented. (PA, v. 62, #4863)

#### 117. BORON TRIFLUORIDE PROPORTIONAL COUNTERS

Abson, W., Salmon, P. G., and Pyrah, S.

*Institution of Electrical Engineers, Proceedings of the, Paper 2542 M*, January 1958 (to be republished in v. 105B, 1958)

The design and manufacture of a variety of types of boron-trifluoride proportional counter used by the U.K.A.E.A. are described. One basic design and method of assembly is used for the manufacture of counters of sizes ranging from  $\frac{1}{2}$  in. diameter and a few inches long to 2 in. diameter and several feet long. The technique of manufacture is suitable for large-scale production, and consistently good electrical characteristics can be obtained. Details are given of the operating characteristics of a wide range of counters, and the effect of circuit parameters on the output pulse amplitude is discussed. Measurements of the  $\gamma$ -response of medium-size counters show that they can be used to discriminate between neutrons and  $\gamma$ -radiation at  $\gamma$  dose-rates of 100-200 rad/hr. The counters can be used for long periods at temperatures up to 100°C without significant deterioration in characteristics. The counting life is found to be a function of counter size and of gas multiplication, and is probably limited by dissociation of  $\text{BF}_3$  and the formation of electron-capturing dissociation products. A typical medium-size counter, e.g., 1 in. diameter by 6 in. long, can be used for  $10^{11}$  counts at a gas-multiplication factor,  $M$ , of 10, before significant deterioration of the counting characteristics occurs. Some applications of  $\text{BF}_3$  proportional counters, such as in reactor instrumentation, and the use of large counter arrays in nuclear physics experiments, are discussed briefly. (PA, v. 61, #669)

#### 118. THE DAMAGE TO PLASTIC SCINTILLATORS BY IONIZING RADIATION

Rozman, I. M. and Zimmer, K. G.

*International Journal of Applied Radiation and Isotopes*, v. 3, pp. 36-42, 1958

The light intensity from plastic scintillators with a polystyrene base is diminished by an increased dose of the  $\alpha$ - and  $\beta$ -radiation received. Moreover, the exposure is accompanied by a decrease in the transmission of the plastic scintillators' own luminescent light. This however is insufficient for quantitative explanation of the observed reduction in the intensity. The decrease in luminescent light yield is connected with radiation damage to the plastic scintillator. The  $\alpha$ -radiation dose required to give

50 percent damage in plastic scintillators is near  $6 \times 10^{11}$  erg/g, i.e., 50 times bigger than that required to damage equally single crystals of anthracene. (NSA, v. 12, #6072)

#### 119. SILICON CRYSTAL COUNTERS

Davis, W. D.

*Journal of Applied Physics*, v. 29, no. 2, pp. 231-232, February 1958

Pulses resulting from  $\alpha$ -bombardment of an impurity-doped single crystal of silicon under an applied field of  $10^4$  volt/cm are described. Using gold electrodes in ohmic contact, the rapid rise of the primary pulses is followed by a much slower rise of secondary current, presumed to arise from the injection of electrons into the crystal by the field of trapped holes close to the cathode. (PA, v. 61, #2440)

#### 120. OPTICAL JOINT FOR HORIZONTAL MOUNTING OF A LARGE SCINTILLATION CRYSTAL

Olde, G. L. and Brannen, E.

*Journal of Scientific Instruments*, v. 36, pp. 244-246, May 1959

The preparation of the optical contact was carried out as follows. A thin layer of silicone oil was spread on the contact surfaces and an O-ring was placed in position. A press fit was made between the contact surfaces while the crystal-phototube unit was maintained in a vertical position. The latex band was snapped into position and the edges fastened to the crystal and the photomultiplier with electrical tape. The assembly was placed in the spectrometer chassis and a constant pressure exerted between the crystal and the phototube by means of a clamping device. A small hole was cut in the uppermost surface of the latex band and silicone oil poured in until the space between the crystal and the phototube was completely filled. This arrangement has shown no leakage over a six-month period and the optical contact efficiency has remained substantially the same. (NSA, v. 13, #14,475)

#### 121. WORK FUNCTION OF ELECTRONS AND PROPERTIES OF GEIGER-MUELLER COUNTERS

Orient, O.

*Magyar Fizikai Folyoirat*, v. 5, pp. 395-403

(Translated from *Referativnyi Zhurnal Mekhanika*, no. 8, 1958, Abstract 17353)

An investigation was made of the influence of the work function of electrons from the material of the cathode of self-quenching Geiger-Mueller counters on their parameters. Cathodes of zinc, cadmium, copper, and nickel were investigated. If the filler and the geometry are the same, counters with cathodes having a larger work function have a longer plateau and a smaller slope than counters with cathodes having a smaller work function. In counters with different cathodes, for identical overvoltages, the quantities of electricity per discharge are approximately the same. This indicates that the number of formed ions is independent of the material of the cathode. (NSA, v. 13, #11,800)

#### 122. MULTIPLE GEIGER COUNTER TELESCOPE MEASUREMENTS OF THE DIRECTIONS OF AIR SHOWER PARTICLES

Rathgeber, H. D.

*Nature*, v. 183, pp. 386-387, February 7, 1959

An experiment on the use of a multiple Geiger counter telescope for measuring the directions of air shower particles is discussed. The experimental arrangement consisted of two Geiger counter telescopes, separated by 1 m, which could be tilted independently around an east-west axis. Each telescope consisted of two counters, 20 cm long and of 3 cm diameter, separated by 14 cm. A third counter could be introduced either in line or just outside the space joining the two outermost counters. The resolving time of  $8 \mu\text{sec}$  gives a rate of accidental counts of  $10^{-3}$  per hr for both the fourfold and sixfold coincidences, the main contribution being the accidental coincidences between the two telescopes. Results of measurements made in a tent at an altitude of 1,750 m are given. Conclusions indicate that such an arrangement of Geiger counters as was used does not respond selectively to showers incident within the opening angle of  $\pm 12$  deg of the telescope. (NSA, v. 13, #7702)

#### 123. HODOSCOPE

*Nauka i Zhizn* (in Russian), no. 8, p. 19, 1957

A brief description is given of the hodoscope installation in the Lenin Mountains. The installation is made up

of more than 4,000 measuring devices and approximately 12,000 tubes with cold cathodes located in 15 laboratories. (NSA, v. 12, #10,830)

**124. AUTOMATIC COUNTING-RATE RECORDER**

Pomerantz, M. A. and Smith, A. E.

*Nuclear Instruments*, v. 2, pp. 49–52, January 1958

A counting-rate recorder, originally designed for a cosmic-ray neutron monitor station, incorporates a scale-shifting arrangement which automatically changes the sensitivity as required in accordance with the input counting rate. (NSA, v. 12, #6731)

**125. AUTOMATIC SINGLE-CHANNEL PULSE-HEIGHT ANALYZER**

Tove, P. A.

*Nuclear Instruments*, v. 2, pp. 1–4, January 1958

An automatic single-channel pulse-height analyzer is described. It works with a variable step attenuator to give 300 channel positions and has constant relative channel width. (NSA, v. 12, #6728)

**126. AN ALL-STEEL GAS PROPORTIONAL COUNTER**

Aliaga-Kelly, D.

*Nuclear Power*, v. 4, no. 36, pp. 111–112, April 1959

A gas proportional counter designed for a particular application is described. The unit is constructed throughout of stainless steel and is a  $4\pi$  counter in which four counting annuli surround a central thin tube which forms the window of the counter. The anode wires are tungsten and the insulators are of the metal-to-ceramic type. All welds were made by the argon-arc process. (NSA, v. 13, #11,803)

**127. G-M COUNTERS**

Van Duuren, K., Jaspers, A. J. M., and Hermesen, J.

*Nucleonics*, v. 17, no. 6, pp. 86–94, June 1959

Several designs of Geiger-Mueller tubes and their applications in radiation detection instruments are discussed. Drawings of nine tube designs are shown and their applications listed. Performance curves for several tubes are shown. (NSA, v. 13, #16,178)

**128. SCINTILLATION COUNTING—1958**

*Nucleonics*, v. 16, no. 6, pp. 54–59, June 1958

A review of developments reported at the sixth Scintillation Counter Symposium, Washington, January 1958. Organic phosphors have been found to have a slow component of decay whose intensity depends on the nature of the ionizing particle. In this way neutrons which cause the emission of a larger proportion of the slow component may be differentiated from  $\gamma$ -rays. Plastic phosphors containing up to 7 percent Pb and giving 50 percent of the pulse-height of the metal-free plastic have been made using salts such as lead octoate methacrylate. The "Vernier Chronotron" measures the time interval between two pulses by causing them to circulate in two delay line loops of slightly different delay times. The number of transits before the pulses arrive in coincidence at a detector gives the time interval in terms of the difference in transit times (1 m $\mu$ sec). New photomultipliers have reduced transit-time spreads by using spherical photocathodes and special optical systems. (PA, v. 62, #1638)

**129. ALL-TRANSISTOR CIRCUITS FOR PORTABLE DETECTORS**

Eichholz, G. G., Alexander, G. E., and Bettens, A. H.

*Nucleonics*, v. 15, no. 11, pp. 90–93, November 1957

Circuits for the operation of G.M. counters and photomultipliers are described. (PA, v. 61, #674)

**130. MEASUREMENT OF THE RISE-TIME OF PULSES IN BF<sub>3</sub> PROPORTIONAL COUNTERS**

Dabek, W. and Kazimierski, A.

*Nukleonika* (in Polish), v. 3, no. 3, pp. 299–312, 1958

A method is described of measuring the rise-time of pulses in a proportional counter. The method is based on the measurement of changes in pulse amplitude produced by the application of differentiating and integrating circuits. The amplifier used in the measurements had a known constant integration time and an additional differentiating circuit of variable time constant. The pulse rise-times measured in three types of proportional counters ranged from 0.3 to 0.9  $\mu$ sec. (PA, v. 62, #1636)

**131. SIZE-SPECTRUM OF EXTENSIVE AIR SHOWERS OF THE COSMIC RADIATION.**

# **I—RESPONSE OF A SINGLE SCINTILLATOR TO EXTENSIVE AIR SHOWERS**

Green, J. R.

*Nuovo cimento, II*, v. 14, no. 6, pp. 1342–1355,

December 16, 1959

This paper is concerned with the expected response of such a scintillator to the extensive air showers. It also presents the results of the experiments as they apply to the size-spectrum of the showers.

## **132. A NEW TYPE OF PULSE-HEIGHT ANALYSER FOR RAPID PULSES**

Rubbia, C. and Torelli, G.

*Nuovo cimento, II* (in Italian), v. 12, no. 2,

pp. 144–147, April 16, 1959

A new type of pulse-height analyzer using a beam deflection tube is described. The use of these tubes allows such a circuit to work at high repetition rate, without structural complexities. (PA, v. 62, #8424)

## **133. APPARATUS SUITABLE FOR SELECTION OF COSMIC RAY PARTICLES OF MASS ABOUT 550 $m_e$**

Conversi, M., De Munari, G. M., Egidi, A., Fiorini, E., Ratti, S., Rubbia, C., Succi, C., and Torelli, G.

*Nuovo cimento, II* (in Italian), v. 12, no. 2,

pp. 130–137, April 16, 1959

The apparatus employed in a search for the 550 mass particles reported by Alihanian, et al., is described. Unwanted particles are eliminated electronically by a suitable arrangement of scintillation–Čerenkov– and G.M. counters. The recorded particles are observed in a large multiplate cloud chamber. The mass is essentially deduced by the combined measurements of range in this chamber and  $dE/dx$  in a proportional liquid scintillator. It is shown that the background of spurious 550 mass particles is entirely negligible and that genuine 550 mass particles could not be missed. (PA, v. 62, #8267)

## **134. A NEW TYPE OF PARTICLE DETECTOR: THE “DISCHARGE CHAMBER”**

Fukui, S. and Miyamoto, S.

*Nuovo cimento, II*, v. 11, no. 1, pp. 113–115,

January 1, 1959

Describes briefly a new type of detector based on

gaseous discharges. It consists of a glass box with metal or conductive glass plates as electrodes, filled with a mixture of neon and argon at atmospheric pressure. A triggered pulsed field of the order of 14 kv per 2 cm and of  $10^{-7}$  sec time constant is applied immediately after passage of ionizing particle, causing small luminous discharges along the trajectory, which can be photographed. Simplicity of construction suggests its use for cosmic rays and with accelerators, especially as it can detect many particles simultaneously. (PA, v. 62, #5968)

## **135. DIRECTIONAL PROPERTIES OF COSMIC RAY TELESCOPES**

Brunberg, E. A.

*Nuovo cimento, II*, Series 10, v. 8, Supplement no. 2,

pp. 237–143, 1958

In the study of cosmic-ray intensity and its time variations, different kinds of recording apparatuses have been used, including ionization chambers and Geiger-Mueller telescopes. In this way different time variations are observed. Knowledge of that part of the variation which is induced by the atmosphere seems now to be fairly well established, but the mechanism of the extra-terrestrial variations is subject to several theories. The optics of cosmic-ray telescopes is discussed. The problem is as follows: given a cosmic-ray source with known spectrum located in a given direction far away from the Earth, what is the counting rate of a telescope on the Earth pointing in a given direction? As in ordinary optics the case of a point source (in this case a cosmic-ray point source) infinitely far away from the Earth is treated. The image (intensity count) given by the telescope is recorded during one day. Using this result it is then possible to deduce the image of any cosmic-ray source. (NSA, v. 13, #7982)

## **136. THE USE OF THE NEON FLASH-TUBE FOR THE PRECISE LOCATION OF PARTICLE TRAJECTORIES**

Ashton, F., Kisdnasamy, S., and Wolfendale, A. W.

*Nuovo cimento, II*, Series 10, v. 8, pp. 615–621,

May 16, 1958

The passage of fast cosmic-ray particles through an array of neon flash tubes has been studied, and the accuracy of location of the particle trajectories has been found to be as high as in conventional cloud chambers. (NSA, v. 12, #12,594)

**137. THE "SABBIONE" COSMIC RAY  
LABORATORY**

Fiorini, E., Giori, C., Succi, C., and Moriggia, C.  
*Nuovo cimento, II* (in Italian), Supplement, v. 7,  
no. 1, pp. 129-138, 1958

Gives details of the design and facilities of a laboratory which has been built at 2518 m above sea-level (46.5°N, 04°W), near the Morasco-Sabbione funicular. (PA, v. 61, #4095)

**138. COUNTING RATE OF COSMIC RAY  
COUNTER TELESCOPES IN INCLINED  
DIRECTIONS**

Tidman, D. A. and Ogilvie, K. W.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 735-738,  
September 1957

If the cross-sectional area of the telescope is not small compared with its length, a correction factor  $f$ , depending upon the geometry of the telescope, must be included in the calculations. Formulas are derived which allow the geometric correction to be evaluated rapidly to sufficient accuracy for most experimental purposes. (NSA, v. 12, #1530)

**139. COUNTING RATE CURVES FOR GEIGER  
COUNTERS AND THEIR GEOMETRY**

Grouse, P. J. and Rathgeber, H. D.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 719-722,  
September 1957

The shape of the counting rate curve for a particular type of Geiger counter has been computed from purely geometrical considerations. Experiments designed to minimize non-geometrical effects support these calculations. General observations are made concerning the effect of design parameters upon counting curves for counters of all designs. (NSA, v. 12, #1529)

**140. OBSERVATIONS ON EXTENSIVE AIR  
SHOWERS. I. APPARATUS**

Cranshaw, T. E. and Calbraith, W.  
*Philosophical Magazine, The*, Eighth Series, v. 2,  
pp. 797-803, June 1957

Deals with an air-shower experiment using G.M. counters in a triangular array covering 0.5 km<sup>2</sup>. Details

are given of the recording apparatus which incorporates a Hollerith machine and, in appendices, of a counter-quenching circuit and a pulse-adding circuit. (PA, v. 61, #218)

**141. PHOTOGRAPHY OF COSMIC RAYS IN A  
LUMINESCENT CHAMBER**

Perl, M. L. and Jones, L. W.  
*Physical Review Letters*, v. 2, no. 3, pp. 116-117,  
February 1, 1959

Minimum-ionizing cosmic rays in a NaI(Tl) crystal were photographed by means of three image-intensifier tubes coupled optically. (PA, v. 62, #5858)

**142. COSMIC RAY RESEARCH FACILITIES IN  
AFRICA AND THE ORIENT**

Korff, S. A.  
*Physics Today*, v. 12, no. 12, pp. 46-47,  
December 1959

Cosmic ray research facilities in the Far East and in South and East Africa are described in this article.

**143. THE SCINTILLATION COUNTER STABILITY  
AMPLIFIER**

Ivanchenko, A. M.  
*Pribery i Tekhnika Eksperimenta* (in Russian),  
no. 2, pp. 150-151, March-April, 1959

A design is suggested for a scintillation counter with a stabilizing device based on the principle of automatically controlled amplification of the linear track along the control signal. (NSA, v. 13, #15,320)

**144. SCALE RECORDINGS IN SCALING SCHEMES**

Akimov, Yu. K.  
*Pribery i Tekhnika Eksperimenta* (in Russian),  
no. 2, pp. 113-114, March-April, 1959

The use of coincidence schemes in scaling devices develops a higher order of precision of the measured chaotically distributed pulses. (NSA, v. 13, #15,318)

**145. IONIZATION CHAMBER FOR THE  
INVESTIGATION OF COSMIC RAYS**

Goryunov, N. N. and Erlykin, A. D.  
*Pribery i Tekhnika Eksperimenta* (in Russian),  
no. 1, pp. 130-131, January-February, 1959

A chamber is described which uses electron collection and in which the working volume is in the form of a cube with each side 25 cm. This permits the compact packing of counters recording cosmic rays over an area. The collecting electrode is a vertical cylinder 1 cm in diameter, 10 cm long, and the chamber is filled to 850 mm pressure with 98 percent A-2 percent N<sub>2</sub>. The operating voltage was 900 v and the effective volume, found by placing alpha emitters in various places in the counter, was 95 percent of the geometrical volume. The field distribution in the cube was found to be 10 percent with the help of a resistance network analogue. Empirical formulae are given for the variation of collector charge with time after uniform ionization of the chamber; most is collected within 50  $\mu$ sec. (PA, v. 62, #8405)

**146. ON THE INFLUENCE OF PULSE ANALYZER CHANNEL WIDTH ON THE SCINTILLATION SPECTROGRAPH RESOLVING POWER**

Tsirlin, Yu. A.

*Pribery i Tekhnika Eksperimenta* (in Russian), no. 5, p. 34, September 1958

**147. IONIZATION CHAMBERS AND APPARATUS FOR STUDYING WIDE ATMOSPHERIC COSMIC RAY SHOWERS**

Bekkerman, I. M., Dmitriev, V. A., et al.

*Pribery i Tekhnika Eksperimenta* (in Russian), v. 4, pp. 31-36, July-August, 1958

Descriptions are given of a 60-liter pulse ionization chamber and its leading amplifier analyzer. The design and treatment of the chamber permit continuous work. Pulses with amplitudes differing by an order of four are recorded, moreover, the minimum pulse corresponds to a single particle path across the chamber. (NSA, v. 13, #3787)

**148. AUTOMATIC RECORDING OF COSMIC RAY OUTBURST**

Blokh, Ya. L. and Korablev, L. N.

*Pribery i Tekhnika Eksperimenta* (In Russian) v. 4, pp. 31-36, July-August 1958

A method for automatically recording the beginning of an increase in the intensity of the hard component of cosmic radiation is described. Increases greater than or

equal to 5 per cent can be measured with an accuracy of less than 0.5 min. The device includes a fast recorder of the number of coincidences seen by a cubic telescope which is also used for the continuous recording of cosmic radiation during the IGY. This telescope consists of three rows of counters with a 10 cm lead screen between the second and the third row. The instrument consists of two independent systems (2 cubes). Coincidences between pulses from the first, second, and third rows are produced by the hard component. Apart from the triple coincidences, double coincidences between the first and the second and the second and the third rows are also recorded. These coincidences are produced by the general and the hard component in a wide solid angle and can be used to determine the soft component. The beginning of the solar outburst is determined from the double coincidences (first and second row) which record the general component. This increases the statistical accuracy and the accuracy of fixing of the beginning of an outburst since the number of 1-2 coincidences is larger by a factor of 2.4 than the number of 1-2-3 coincidences. In addition, the 1-2 coincidences record the general component which in itself is more sensitive to solar outbursts than the hard component. In summing up the number of double 1-2 coincidences the total number of pulses increases to 240,000 per hour which in half-a-minute gives the statistical accuracy of  $\pm 2.2$  percent. In order to increase the stability of the working threshold, the recorded radiation is compared with the frequency of the standard oscillator which is stable to 0.1 to 0.01 percent. The comparison is carried out by means of a discrete count of the radiation pulses and the pulses from the oscillator. (NSA, v. 12, #10,712)

**149. A FAST-ACTING DIFFERENTIAL COINCIDENCE CIRCUIT**

Akimov, Yu. K.

*Pribery i Tekhnika Eksperimenta*, no. 4, pp. 98-99, 1957

A description is given of a fast-acting differential coincidence circuit. The input elements of the apparatus are two coincidence circuits. Each of these is connected to two pulse detectors, one directly and the other via a delay cable. The result of such connections is that the output pulses of both circuits will be equal in amplitude at coincidence but different at non-coincidence. The difference in the pulses is obtained by the differential stage. After

amplification, the difference pulse, which is the anti-coincidence signal, suppresses the pulse which is being transferred from one of the coincidence circuits to the counting apparatus. The result is that only coincidence pulses which are not accompanied by difference pulses are recorded. The circuit diagram is given. The circuit recorded the self-coincidence of pulses from a counter, which consisted of a photomultiplier B-1 and a solution of terphenyl in phenylcyclohexane, scintillating under the action of irradiation from  $\text{Co}^{60}$ . The photo-multiplier was loaded by a  $75\ \Omega$  cable. The amplitude of the pulses was  $\leq 0.5$  v. The self-coincidences were broken by cables of different lengths  $l$ . The count rate of the pulses in relative units were with  $l = 0$ ,  $-1$ , with  $l = 5$  cm,  $-0.3$ , with  $l = 10$  cm,  $-0.02$ , and, with  $l = 10$  cm, tended to zero, which corresponded to a time resolution  $\sim 2 \times 10^{-10}$  sec. For recording coincidences from two scintillation counters, it is necessary to consider not only the time variation but also the amplitude variation of the coincident pulses. If this difference is not very great, then it can be limited to some value of the resolving time due to amplification of the discrimination of the difference signal. With large variation, it is necessary to make the signal symmetrical by using forming lines and to move these pulses relative to each other as measured on their half-widths. The circuit is primarily useful for analysis of fast particles with time-spans differing by  $\Delta t \leq 10^{-9}$  sec. (NSA, v. 12, #10,845)

**150. ANOMALOUS DISCHARGE COUNTERS AS DETECTORS OF COSMIC RAY NUCLEONIC COMPONENT**

Akpinar, S.

*Revue de la Faculté des Sciences d l'Université d Istanbul*, v. 22, no. 3, pp. 243-255, July 1957

The giant pulse counter described by Gursey has differential sensitivity and can discriminate between heavily ionizing particles and electron showers. Measurements were made on the intensity changes between sea level and 1900 m. Relative cross sections for nuclear interactions with Cu and Al were also measured. (PA, v. 62, #3683)

**151. SLIDE RULE FOR THE PRESSURE CORRECTION OF COSMIC RAY DATA**

Storey, J. R. and McCracken, K. G.

*Review of Scientific Instruments, The*, v. 31, no. 3, pp. 347-348, March 1960

**152. TEN-Mc PULSE-AMPLITUDE DISCRIMINATOR**  
Mey, J.

*Review of Scientific Instruments, The*, v. 30, no. 4, pp. 282-284, April 1959

A pulse-height discriminator has been developed which is capable of operating at repetition rates up to 10 Mc. It accepts positive input pulses with a threshold adjustable from 1 to 11 v. The output signal is of constant shape and amplitude. The circuit is described and test results are given. (PA, v. 62, #8426)

**153. COSMIC-RAY INSTRUMENTATION IN THE FIRST U.S. EARTH SATELLITE**

Ludwig, G. H.

*Review of Scientific Instruments, The*, v. 30, pp. 223-229, April 1959

The first U.S. Satellite, *1958 Alpha (Explorer I)*, carried instrumentation to measure cosmic-ray intensity, micro-meteorite impacts, and temperatures within the satellite. The instrumentation was designed with emphasis on conservation of electrical power, on stable and reliable operation, on operation over a wide range of temperatures, and on compactness and mechanical ruggedness. The cosmic-ray instrumentation in *1958 Alpha* operated according to expectations, providing several hundred recordings of data received during transits over ground stations. These data led to the discovery of a belt of high-intensity radiation around the Earth. (NSA, v. 13, #12,619)

**154. SPECTRAL EFFECTS IN THE COMPARISON OF SCINTILLATORS AND PHOTO-MULTIPLIERS**

Swank, R. K. and Buck, W. L., Hayes, F. N., and Ott, D. G.

*Review of Scientific Instruments, The*, v. 29, pp. 279-284, April 1958

Photomultiplier evaluation of scintillation performance is considered in the light of its marked dependence on spectral shape effects in the emission spectrum of the scintillator, in photon absorption of cell, reflector and photomultiplier window, and in the photoelectric conversion process. Relative pulse height data indicating gross

differences in spectral sensitivity are presented for a group of 132 photomultipliers (types 6292 and 6342). A fluorescent converter for measuring the quantum output of liquid scintillators is described. Six scintillator solutions with fairly evenly spaced mean emission wavelengths from 3360 to 4660Å are evaluated for relative pulse height and relative photon output. Suggestions are presented for desirable methods for measuring the performance of scintillators. (NSA, v. 12, #9960)

#### 155. TWO-DIMENSIONAL PULSE-HEIGHT ANALYZER

Birk, M., Braid, T. H., and Detenbeck, R. W.  
*Review of Scientific Instruments, The*, v. 29,  
pp. 203-209, March 1958

A two-dimensional analyzer classifies a coincidence event between two detectors according to both pulse amplitudes. The events are sorted into "channels" covering a plane instead of the linear array of a conventional analyzer. For coincidence measurements in which the amplitude spectrum from one detector is examined as a function of the pulse height from the other over a wide range, such a device provides maximum efficiency in recording the data. As analyzer is described, in which each coincidence is recorded on a punched paper tape memory as a pair of correlated numbers (the two pulse heights) in binary notation (1-127). In the subsequent read-out these two numbers specify a two-dimensional channel. To examine the information in a particular region of the plane, a circuit controlled by a mechanical tape reader determines those events for which one coordinate lies in a preselected range. The corresponding coordinates are then displayed as a spectrum on a conventional 100-channel analyzer by a digital-to-analog conversion system in such a way that each event appears in the channel whose number is punched on the tape. The maximum recording rate is 8/sec; read-out is at 10/sec. The maximum number of channels is  $(127)^2$ . In experiments with low coincidence rates the time taken to record and analyze such data is very considerably less than by conventional methods. Examples are given of the application of the analyzer to a  $(p, p'\gamma)$  experiment and to the identification of energetic charged particles by measuring simultaneously their energy and differential energy loss. (NSA, v. 12, #7956)

#### 156. LIQUID SCINTILLATORS FOR FREE NEUTRINO DETECTION

Ronzio, A. R., Cowan, C. L., Jr., and Reines, F.  
*Review of Scientific Instruments, The*, v. 29, no. 2,  
pp. 146-147, February 1958

The criteria by which liquid scintillators have been selected and developed for free neutrino detection experiments are described and a discussion is given of the preparation of the solutions. Triethylbenzene is a superior solvent and cadmium octoate is found to be the best cadmium compound known for these purposes. (PA, v. 61, #2439)

#### 157. LARGE SCINTILLATOR FOR OBSERVATION OF COSMIC RAYS

Green, J. R.  
*Review of Scientific Instruments, The*, v. 29, no. 1,  
pp. 10-14, January 1958

A liquid scintillator having an area of five square meters was developed for the observation of the extensive air showers in cosmic rays. The scintillating liquid, in the form of a disk 10 ft in diameter and 6 in. deep, is viewed by a single 14-in. Dumont type K1328 photomultiplier tube. The associated circuitry provides a gate whose length is proportional to the logarithm of the scintillator pulse-height over a range in pulse height of 2000:1. The length of this gate can be either measured and recorded on a Berkeley EPUT timing meter or converted linearly to a pulse height and analyzed by a multichannel discriminator. (PA, v. 61, #2438)

#### 158. SPIRAL CAPILLARY PLASTIC SCINTILLATION FLOW COUNTER FOR BETA ASSAY

Funt, B. L. and Hetherington, A.  
*Science*, v. 129, pp. 1429-1430, May 22, 1959

Tracer counting of beta emitters in aqueous solution was performed with a detector fabricated from a plastic scintillator capillary. The detector exhibits low gamma background and reproducible detection efficiency, and it requires minimum sample preparation. Counting efficiencies were determined for aqueous solutions of  $p^{32}$ ,  $Na^{22}$ , and  $C^{14}$ , and for  $C^{14}O_2$  gas. (NSA, v. 13, #14,494)



**159. ON THE  $\mu$ MESON TELESCOPE USING PLASTIC SCINTILLATORS**

Kawasaki, S. and Miyazaki, Y.

*Journal of the Scientific Research Institute, Tokyo*, v. 52, pp. 1-10, March 1958

A  $\mu$ -meson detector using plastic scintillators was constructed for the observation of cosmic rays in the Japanese Antarctic Research Expedition. The design and the performance of the telescope are described and some preliminary experimental results are discussed. (PA, v. 61, #6011)

**160. ON THE STANDARD COSMIC-RAY MESON MONITOR**

Kawasaki, S., Kondo, I., Wada, M., and Miyazaki, Y.

*Journal of the Scientific Research Institute, Tokyo*, v. 51, pp. 107-137, September 1957

A standard cosmic-ray meson monitor has been constructed and set up. The monitor was designed in conformity with the general specifications designated by the IUPAP Sub-Commission on Cosmic Ray Intensity Variations (SCRIV). Telescopes of wide angle to total vertical hard components and oblique incident hard components were built together with the standard cubical telescopes. (NSA, v. 12, #3070)

**161. ON THE STANDARD COSMIC-RAY NEUTRON MONITOR**

Kidama, M., Murakami, K., Takeuchi, H., and Miyazaki, Y.

*Journal of the Scientific Research Institute, Tokyo*, v. 51, pp. 37-53, June 1957

**162. HEAVY NUCLEI FLUX IN THE PRIMARY COSMIC RADIATION AT A GEOMAGNETIC LATITUDE OF  $31^\circ$  N**

Alekseeva, K. I. and Grigorov, N. L.

*Soviet Physics-JETP*, v. 37, no. 2, pp. 271-279, February 1960

The flux of primary heavy particles in the stratosphere was measured with apparatus consisting of a telescope surrounded by hodoscope counters and of two pulse ionization chambers placed between the trays of the telescope counters.

**163. NEW DEVELOPMENTS IN SCINTILLATION COUNTERS**

Hanle, W. and Schneider, H.

*Zeitschrift für angewandte Physik* (in German), v. 10, no. 5, pp. 228-248, May 1958

An up-to-date review of scintillation counters is given, including comparison of different types of photomultiplier, associated circuits and phosphors. Inorganic crystals, organic crystals and liquids and plastic phosphors are included. A large section is devoted to recent uses of the counter in nuclear studies. (PA, v. 62, #1640)

**164. THE DISCHARGE PROCESS IN PROPORTIONAL COUNTER TUBES**

Keck, C.

*Zeitschrift für angewandte Physik* (in German), v. 9, no. 6, pp. 286-292, June 1957

A theoretical description of discharge in the proportional region is put forward. Consideration of the intensities and shapes of the electric fields in cylindrical counters yield equations which fit experimental values for the amplification factor  $A$ .  $A$  is shown to depend more on the radial dimension  $\rho$  of the active zone of the counter than on the ionization cross section,  $\rho$  appears to be significantly larger than has been previously assumed. Curves show the variation of  $A$  with pressure, applied potential, geometry and with the addition of quenching gases. (PA, v. 61, #8181)

**165. STUDIES OF FAST DEUTERONS AT THE 3200 m ALTITUDE**

Badalyan, G. V.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 35, pp. 303-305, July 1958

An improved magnetic spectrometer coupled with two large-multiplate Wilson chambers was used in the investigation of cosmic radiation deuterons at 3200 m altitude. Deuterons were identified by the pulse measured in the magnetic spectrometer and by the ionization track in the lower portion of the chamber. The new installation permitted the separation of ionized particle from non-ionized and the observation of particle track and the incidents of local generation of particles in the chamber material. (NSA, v. 12, #17,495)

**166. METHOD OF MEASURING THE ENERGY  
OF PARTICLES IN THE RANGE HIGHER  
THAN  $10^{11}$  ev**

Grigorov, N. L., Murzin, V. S., and Rapaport, I. D.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 34, pp. 506-507, February 1958

The design and performance of an apparatus for the determination of the energy of an individual nuclear active particle are outlined. The principle of the instrument is based on the measurements of the total energy released by the secondary particles which formed during the passage of the initial particle through a thick layer of a substance. Experimental data obtained with such an

apparatus at 3860 m above sea level are included. (NSA, v. 12, #9340)

**167. ELECTRON SPECTRUM AT 3200 m ABOVE  
SEA-LEVEL**

Dalon, M. I.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, no. 5(11), pp. 1166-1174, 1957

Using a magnetic spectrometer coupled with a multi-plate cloud chamber, a momentum spectrum was obtained of cosmic-radiation electrons in the momentum interval from  $4 \times 10^8$  to  $4 \times 10^9$  ev/c. The problem of the penetrability of fast electrons ( $E \geq 4 \times 10^8$  ev) is considered. (PA, v. 61, #6017)

## C. Measurements

### Reports

#### 168. PHYSICS DIVISION PROGRESS REPORT

[FOR] APRIL 1, 1958 TO JUNE 30, 1958

Atomic Energy of Canada Ltd.,

Chalk River Project, Chalk River, Ont.

PR-P-38 (74 pp.)

AECL-673

Mechanisms for thermonuclear reactions in stars were investigated in an attempt to explain  $\text{Cf}^{254}$  production. The gamma branching ratio for  $\text{Rb}^{86}$  was measured as  $8.7 \pm 0.2\%$ . Fission product mass distributions were obtained for  $\text{U}^{235}$ . Energy levels, spins, and parities are tabulated for  $\text{O}^{18}$ . Energies and intensities were measured for four gamma rays from the reaction  $\text{Mg}^{26}(\alpha, n, \gamma)\text{Si}^{30}$ . Excitation energies and excitation cross section ratios are tabulated for  $\text{F}^{19}$ ,  $\text{Na}^{23}$ ,  $\text{Ti}^{47}$ , and  $\text{Mn}^{55}$  excitation by  $\text{He}^3$  and  $\text{He}^4$ . Calculations of gamma transition probabilities were carried out for excited levels in  $\text{F}^{18}$ . Neutron detectors were evaluated for their applicability to (p, n) threshold experimentation in tandem accelerators. Initial tests on the Chalk River tandem Van de Graaff accelerator are described. Gamma energies, spins, and parities were determined for levels in  $\text{B}^{11}$  resulting from the reaction  $\text{Li}^7(\alpha, \gamma)$ .

An unusually abrupt decrease in cosmic radiation occurred on February 11, 1958. The variation as detected by three counters is tabulated. Neutron spectrometer and spectrometer data recording equipment developments are reviewed. Gamma energies are tabulated for (n,  $\gamma$ ) reactions in  $\text{Gd}^{157}$ ,  $\text{Te}^{123}$ ,  $\text{Ti}$ ,  $\text{Mg}^{25}$ ,  $\text{S}^{33}$ , and  $\text{P}^{32}$ . Pressure effects on neutron scattering in liquid He were measured between 3.7 and 21.4 atmospheres. The new NRX control system was completely tested and put into regular use. Basic studies of transistor pulse amplifiers were continued. The convergence of the spherical harmonics approximation to the extrapolated end-point,  $Z_0$ , and the current-to-flux ratio,  $i(o)/e(o)$ , in the Milne problem was examined. The results are given from neutron resonance absorption studies of an NRX natural U rod. Work was continued on the development of the mathematics for describing neutron spectra in the vicinity of absorbing slabs. The many-level formula was used in examining neutron resonances in  $\text{Pu}^{239}$ . The model of a nucleus obtained using a cut-off oscillator potential as a single particle single potential was improved by introducing

separate potentials for neutrons and protons. (For preceding period see PR-P-37.) (NSA, v. 12, #16,634)

#### 169. SEVENTH ANNUAL REPORT OF THE WORK OF THE BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE

Mandeville, C. E.

September 30, 1957

Bartol Research Foundation, Swarthmore, Penna.

NP-6619 (111 pp.), N6ori-144

A description of work on lifetimes of the 4.43 Mev excited state of  $\text{C}^{12}$  and the 4.46 Mev excited state of  $\text{B}^{11}$  is given. The study of resonance fluorescence using radioactive isotopes as the sources of the exciting radiation was limited to the investigation of  $\text{As}^{75}$  using the radiation from  $\text{Se}^{75}$ . Information on the nature of the photosensitivity of Geiger counters is presented. The activities of the cosmic ray program are outlined, particularly balloon flights, the shipboard neutron monitor, and the Thule neutron monitor. (NSA, v. 12, #7294)

#### 170. SPACE RADIATION AS AN ENVIRONMENTAL CONSTITUENT

January 15, 1960

Battelle Memorial Institute,

Radiation Effects Information Center,

Columbus, Ohio

Memorandum 19

The space-radiation data presented here include particle identifications, energy spectra, flux levels, and altitude coordinates obtained from U.S. and USSR Earth satellites and lunar probes.

#### 171. MAGNETIC AND COSMIC RAY STORMS

Trumpy, B.

1959

Universitetet i Bergen Arbok, Norway

Detailed studies on individual cosmic-ray storms in different components of the cosmic radiation were carried out for the Norwegian stations at Tromso and Bergen and for foreign stations in Germany, Japan and Tasmania. For each component, individual cases were investigated regarding the increasing phase displacement with increasing storm time between the amplitudes of the magnetic

and cosmic ray storms. The amplitude of individual cosmic ray storms were measured for the neutrons, the soft component, the total radiation and for different hard components. In this way, valuable information is obtained regarding the dependence of the amplitude of a cosmic ray storm on the mean energy of the primaries which have produced the cosmic ray component in question. The dependence of cosmic ray storms on the geomagnetic latitude was investigated for different radiation components. The diurnal variation of cosmic ray storms was studied in a series of cases for different components and for mesons incident from different directions. Special cases of increases of the cosmic ray intensity and their dependence on the geomagnetic latitude were reported for a period of intense solar flare activity, September 18–23, 1957. Different possibilities for a theoretical description of the cosmic ray storm phenomena and their connection with solar activity and magnetic storms are discussed. (PA, v. 62, #5864)

#### 172. CHARGE SPECTRUM OF THE HEAVY PRIMARY COSMIC RAYS

Stern, E. A.

1955

California Institute of Technology,  
Guggenheim Aeronautical Laboratory,  
Pasadena, Calif.

Thesis

A measurement at  $\lambda = 55^\circ$  and 95,000 feet has been made of the heavy primary cosmic ray charge spectrum ( $Z > 3$ ) by means of a pulse ionization chamber. The characteristics of the chamber and associated electronics are described.

#### 173. OBSERVATIONS ON HEAVY PRIMARY COSMIC RAY NUCLEI ABOVE THE ATMOSPHERE

Yagoda, H.

July 1958

Air Force Cambridge Research Center,  
Bedford, Mass.

AFCRC TR-58-241, Geophysical Research Papers  
No. 60 (29 ref.)  
(ASTIA AD-152,585)

The flux of heavy primaries of  $Z > 6$  was evaluated from small emulsion blocks flown on Aerobee rockets specially designed to keep condensed matter below  $0.2 \text{ g/cm}^2$  after penetrating the atmosphere. Parachute recoveries were effected from a day and a night flight, yielding  $J_s^0 = 4.85 \pm 0.95$  and  $5.05 \pm 0.88 \text{ (m}^2 \text{ sec sterad)}^{-1}$ , respectively, suggesting the absence of a pronounced day-night effect in the total heavy primary flux. The average for the two Aerobee flights is  $J_s^0 = 4.98 \pm 0.65$  and the  $M^0/H^0$  ratio is  $1.91 \pm 0.55$ . This is in good agreement with a Viking rocket flight made in 1954 for which  $J_s^0 = 5.38 \pm 0.58$  and  $M^0/H^0 = 2.01 \pm 0.50$  when the omnidirectional fluxes are averaged over the entire zenith angle spread accepted by the emulsions along the rocket trajectories. Balloon observations from the same geomagnetic locality ( $41^\circ\text{N}$ ) yield a vertical flux about 1.61 times greater than the rocket observations, in good agreement with geomagnetic theory which predicts small fluxes at zenith angles greater than  $45^\circ$ . Based on the interactions of  $L$  and  $S$ -nuclei and their mean free paths in emulsion, the  $L^0/M^0$  ratio is estimated to be  $0.26 \pm 0.09$ , which favors a smaller flux of Li-Be-B nuclei at the top of the atmosphere than in most extrapolations of balloon observations. A study of the mode of fragmentation of the heavy primaries suggests that secondary  $L$ -nuclei are produced more frequently at rocket elevations than in balloon exposures.

#### 174. A SUMMARY OF THE BERKELEY CONFERENCE ON BIOLOGICAL EFFECTS OF COSMIC RAYS AND ACCELERATED HEAVY IONS

Tobias, C. A., Mel, H. C., and Simons, D. G.

March 10, 1958

California, University of, Radiation Lab., Berkeley  
UCRL-8201 (14 pp.) W-7405-eng-48

An informal conference was arranged for January 21 and 22, 1958, to discuss the present status of knowledge of biological hazards of primary cosmic rays in space flying and to plan avenues of research that should lead to more definite knowledge. A program of the meeting and a summary of the recommendations resulting therefrom are presented. (NSA, v. 12, #8243)

**175. COSMIC RAYS AS A SOURCE OF THE GALACTIC RADIO EMISSION**

Ginzburg, V. L.

Hope, E. R., Translator

June 18, 1954

Canada, Defence Scientific Information,

Service Report

(ASTIA AD-44,769)

The results of an analysis of the acceptability or inacceptability of cosmic electron data are presented. The data are obtained by assuming that the observed general radio emission of the galaxy or the emission from individual discrete sources is the product of a Bremsstrahlung of relativistic electrons in interstellar and circumstellar magnetic fields, and by showing what the intensity of the corresponding cosmic ray particles should be if the magnetic field intensity is known.

**176. OBSERVATIONS OF LOW ENERGY SOLAR COSMIC RAYS FROM THE FLARE OF AUGUST 22, 1958**

Anderson, K. A., Arnoldy, R., et al.

AUGUST 22, 1958

Iowa, State University of, Iowa City

SUI-59-9

Observations have been made of protons at balloon altitudes in the energy range 100 to 300 Mev following a solar sequence of optical flare, r-f noise bursts and long enduring noise storm. Other particles are shown to have low upper limits to their abundance. The flare particles continue to be observed for at least two days and arguments are given to show that their storage and emission takes place in the solar atmosphere. The differential energy spectrum is derived from ionization vs. atmospheric depth data and is found to be  $E^{-5} dE$ . Observations by riometer and VHF scatter propagation paths over the polar regions indicate that solar acceleration of protons up to roughly 100 Mev energy is rather frequent.

**177. RADIATION MEASUREMENT FROM EXPLORER IV**

Van Allen, J. A., McIlwain, and Ludwig

August 20, 1958

Iowa, State University of, Iowa City

SUI-58-8

Preliminary results received from *Explorer IV* during its first two weeks in orbit are presented. The detectors

consist of 1 and 1.5 g/cm<sup>2</sup> Geiger counters and two scintillation counters, one connected to a pulse amplifier and discriminator and the other connected to a nonlinear network and electrometer. (NSA, v. 13, #9116)

**178. SOFT RADIATION EVENTS AT HIGH ALTITUDE DURING THE MAGNETIC STORM OF AUGUST 29-30, 1957**

Anderson, K. A.

January 1958

Iowa, State University of, Iowa City

SUI-58-3

The close connection between the appearance of X-rays in the 100 kev energy region and storm type decreases in the local geomagnetic field is shown. The observation that bears on the point is consistent with these X-rays being produced by electron bremsstrahlung in the terrestrial atmosphere. There are features of the X-ray behavior which show that the primary electrons must be local in character quite apart from geomagnetic cutoff considerations. By local is meant that the electrons either acquire the main part of their kinetic energy in the neighborhood of the Earth or that they are accelerated at the Sun, are trapped in magnetic clouds and drift to the Earth where they are released. It is suggested that accelerations of electrons is a rather general characteristic of the region surrounding the Earth and that their association with aurorae and geomagnetic storms may be special features. (NSA, v. 12, #6664)

**179. NOTE ON PRIMARY COSMIC RAY PROTON AND ALPHA FLUX NEAR THE GEOMAGNETIC EQUATOR**

McDonald, F. B.

1957

Iowa, State University of, Iowa City

SUI-57-9 (20 ref.), N9onr-93803

(ASTIA AD-137,401)

(See also *Physical Review, The*, v. 109, no. 4, pp. 1367-1375, February 15, 1958)

The vertical flux of primary protons and alpha particles was measured at Guam, Marianas Islands ( $\lambda = 3^\circ\text{N}$ ) with a Čerenkov scintillation detector which was carried to a residual pressure of 6.1 g/cm<sup>2</sup> by a Skyhook balloon. The primary alpha flux,  $J_{\alpha}$ , was  $18.0 \pm 2$  particles/m<sup>2</sup> sec sterad at 0 g/cm<sup>2</sup> atm depth. The flux of primary protons, at the upper limit, was  $115 \pm 12$  particles/m<sup>2</sup>

sec sterad at 0 g/cm<sup>2</sup> atm depth. At the lower limit, the flux was  $95 \pm 12$  particles/m<sup>2</sup> sec sterad at 0 g/cm<sup>2</sup> atm depth. This flight completed an extensive latitude survey of the alpha and proton components with identical detectors at all latitudes. The alpha energy spectrum can be represented from 0.150 to 7.3 Bev/nucleon by

$$J_{\alpha}(\geq E) = - (1.5) (415) \int_E^{\infty} \frac{1 - \exp(-80 E'^3)}{(1 + E')^{2.5}} dE'$$

particles/m<sup>2</sup> sec sterad, where  $J_{\alpha}(\geq E)$  is the vertical flux of primary alphas with kinetic energy  $\geq E$  (measured in Bev/nucleon). This energy spectrum was in excellent agreement with the measured low-energy alpha differential energy spectrum. The proton energy spectrum in the latitude range 0 to 41°N (15.2 to 4.0 Bev/nucleon) was represented by  $J_p(\geq E) = 6600/(1 + E)^{1.5}$  particles/m<sup>2</sup> sec sterad. The flux of protons and alphas had the same energy dependence over a wide range of energies. Values of the flux of splash albedo at  $\lambda = 3^\circ$ N were given and estimates were made of the magnitude of the returning albedo correction.

**180. STUDY OF GEOMAGNETIC CUT-OFF ENERGIES AND TEMPORAL VARIATION OF THE PRIMARY COSMIC RADIATION**  
McDonald, F. B.

April 1957

Iowa, State University of, Iowa City  
N9onr-93803, SUI-57-8 (20 ref.)

(ASTIA AD-132,117)

See also entry no. 439.

**181. NEWS IN THE STUDY OF COSMIC RAYS**  
Chudakov, A. and Vyernov, S.

Zygielbaum, J. L., Translator

March 12, 1959

Jet Propulsion Laboratory, California Institute of Technology, Pasadena

DA-04-495-ORD-18

(Pravada, March 6, 1959, Translation USSR)

**182. SCIENTIFIC RESULTS FROM THE EXPLORER SATELLITES**

Hibbs, A. R.

June 2, 1958

Jet Propulsion Laboratory, California Institute of Technology, Pasadena

EP 514

A brief history is given of *Explorer* satellite launchings together with a description of payload instrumentation. A summary is presented of results of experiments made in the following areas: (1) Temperatures of both cases and internal instrumentation; (2) Micrometeorite activity; and (3) Cosmic ray intensity. The results of preliminary analyses of these various measurements as carried out by the responsible institutions are given, together with a discussion of their implications for future measurements of this type.

**183. PROGRESS REPORT NO. 52 [FOR]**

DECEMBER 1, 1957 THROUGH FEBRUARY 28, 1958

February 28, 1958 (87 pp.)

Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge

AT (30-1)-905, Nonr-1841 (16), AECU-3772

Some approximate values of the concentrations of the chlorine ion and the mean activity coefficients of HCl in Dowex 50, as functions of the mean activity of HCl are given. The KCl uptake by anion-exchange resins, Dowex 1 and 2, is plotted. Ion-exchange phase properties of HCl were determined from freezing point measurements. The thermodynamic acid dissociation constants of HClO<sub>4</sub>, HCl, HNO<sub>3</sub>, HBr, and HGaCl<sub>4</sub> in water-saturated bis(2-chloroethyl) ether, were obtained from conductometric measurements. The distribution behavior of InBr<sub>3</sub> and InCl<sub>3</sub> in HBr and HCl was studied. Information is given on the extraction of Zn and Ag from chloride solutions by dioctylamine salts. Ion exchange equilibria between hexammino-cobalt(III) and chloro-pentammino-cobalt(II) ions in respect to La ions in Dowex 50 NaR are plotted. Typical radiochemical activation analyses for K in geologic materials are tabulated. The postulated nuclear level scheme and the calculated and experimental positron decay following ( $\gamma, n$ ) activation of Br<sup>79</sup> are shown for Br<sup>78</sup>. Cumulative fission yields in the deuteron fission of U<sup>235</sup> are tabulated. Cosmic ray data obtained with a new high-counting rate meson monitor are plotted. The equipment used and data obtained in a search for long-lived particles with mass  $\sim 550m_e$  in the cosmic-ray flux at sea level are shown. The excited states of Ni<sup>59</sup> and Ni<sup>61</sup> obtained from ( $d, p$ ) reactions of Ni<sup>58</sup> and Ni<sup>60</sup> are tabulated. (NSA, v. 12, #12,308)

184. ANNUAL PROGRESS REPORT [COVERING]  
RESEARCHES DURING THE PERIOD  
JUNE 1, 1956 TO MAY 31, 1957  
Massachusetts Institute of Technology, Laboratory  
for Nuclear Science, Cambridge  
Report No. 45 (230 pp.)  
AT (30-1)-905, Nonr-1841(16), AECU-3580

Results of solvent extraction studies on Au, Ga, Nb, and Ta are given. Data on the dependence of  $B_A$ ,  $\epsilon_A$  and  $S_A$  on A and on nucleon shells in beta decay are summarized. Rates of hydrolysis of benzyl and benzhydryl halides and methyl iodide in  $H_2O$  and  $D_2O$  are tabulated. Values for the solvolysis of triphenylmethyl fluoride, the decarboxylation rates of  $\beta$ -keto acids, and the decomposition of single chlorosulfites are included. Experiments were conducted to examine the velocity spectrum of cosmic ray  $\mu$ -mesons at sea level, the incidence of air showers and their direction of arrival at sites in Bolivia and India, short period fluctuations in cosmic ray intensity, the  $\mu$ -meson component of large air showers, polarization of cosmic ray  $\mu$ -mesons, and other related measurements. Photographic emulsion research continued on the dynamics of  $K^+$  scattering and on a search for the Pais-Piccioni effects. The linear accelerator work centered about a study of  $\gamma$ -ray induced neutron spectra of Bi, Pb, Au, and Ta. The Rockefeller Van de Graaff generator work was concerned with the measurement of g-factors of low-lying excited states of Sm, Nd, and Gd. Nuclear energy level studies using the ONR Van de Graaff generator were concentrated largely on the nuclei between mass numbers 40 and 70. Efforts were directed toward a determination of level order and, where possible, of spins and parities of states. A number of angular distribution studies for deuterium stripping reactions were carried out. Research with the MIT cyclotron involved a continuation of the angular distribution studies of elastically scattered 7.5-Mev protons, the measurement of polarization of such elastically scattered protons; 30-Mev  $\alpha$  particle scattering,  $\alpha$  particle and deuteron induced reactions and the development of apparatus for time-of-flight neutron energy measurements. (NSA, v. 12, #2441)

185. THE FLUX AND ENERGY SPECTRUM OF  
COSMIC RAY  $\alpha$ -PARTICLES DURING SOLAR  
MAXIMUM  
Freier, P. S., Ney, E. P., and Waddington, C. J.  
December 1958  
Minnesota University School of Physics,  
Minneapolis  
TR on Cosmic Ray Program (11 ref.)  
Nonr-71019  
(ASTIA AD-208,421)

The fluxes of primary cosmic ray  $\alpha$ -particles over Minnesota and Texas were measured during the present period of maximum solar activity. A value of  $136 \pm 9$   $\alpha$ -particles/ $m^2$  sec sterad was measured over Minnesota and of  $68 \pm 4$   $\alpha$ -particles/ $m^2$  sec sterad over Texas. In both cases these values are significantly lower than those observed at solar minimum. The energy spectrum of these particles was determined between 200 Mev/nucleon and 3.0 Bev/nucleon. Results show that the slope of the integral spectrum is less than that observed at solar minimum and that a significant number of low energy particles is still present. A possible mechanism for these changes is discussed briefly. The determination of energies of particles from a measurement of their ionization is discussed in detail.

186. GEOMAGNETIC MEASUREMENTS ON  
HEAVY PRIMARY COSMIC RADIATION  
NEAR THE EQUATOR  
Danielson, R. E.  
September 1958  
Minnesota, University of, School of Physics,  
Minneapolis  
Technical Report, Nonr-710(19) PB-142,692

The zenith and azimuthal angular distribution of primary cosmic radiation with charges  $Z \geq 6$  has been measured near the equator (at Guam) using horizontal emulsions with known orientation relative to the Earth. The observed distribution is well described using a centered dipole magnetic field when the effect of the solid Earth is included by using the main cone as the allowed cone. This report determines that observed distribution is consistent with the centered dipole approximation to the Earth's surface magnetic field (north pole at 79°N and 70°W).

# 187. COSMIC RAY PROGRAM

September 1, 1956–September 1, 1957

Minnesota University, School of Physics,  
Minneapolis

Annual PR and TR, Nonr-71019  
(ASTIA AD-155,313)

The primary alpha particle spectrum over North America and geomagnetic cutoff energies: the equivalent cosmic ray latitudes in the U.S. are  $6^\circ$  higher than conventional geomagnetic latitudes, and British and Continental latitudes are  $6^\circ$  lower. This has great bearing on the calculation of energy spectra from observations of cosmic rays at various latitudes. Angular correlation in the decay of pions and muons: the results with about 6200  $\pi\mu$  decays show that the measured distribution is significantly different from isotropy, both in latitude and longitude. A cosmic ray jet in the  $10^{15}$  electron volt energy range: a 22.4-1 stack of emulsions was exposed in Minnesota during September 1956 in a balloon flight at 116,000 ft. In the 9 radiation lengths of the Minnesota portion of the stack, the jet multiplied from 9 particles, mainly in 2 cores, to 8000 particles. Geomagnetic effects on heavy primary cosmic radiation at  $42^\circ\text{N}$  latitude: the results indicate that the east-west effect is normal in direction, and that angular distribution, as a function of zenith angle, shows none of the shadow cone effects predicted by Schremp. Large cosmic ray decrease accompanying solar maximum 1957: two types of observations at balloon altitudes show a very large decrease compared with 1955 and 1956. The primary alpha particle intensity at sunspot maximum: the alpha particle data showed that a decrease occurred throughout the spectrum and that, even though both low and high energy particles are reduced in intensity, some low energy particles can still arrive. Azimuthal alpha particle distribution at Guam: preliminary results indicated that the east-west asymmetry is not as large as expected.

Surveys the work carried out between 1949 and 1956 on the spectrum of  $\mu$ -mesons and their interactions, penetrating showers and extensive showers, using counters and cloud-chambers. (PA, v. 61, #1747)

# 189. NUCLEAR INTERACTIONS IN THE ENERGY REGION $10^{10}$ ev– $10^{14}$ ev

Ciok, P., Coghen, T., Gierula, J., Holynski, R.,  
Jurak, A., Miesowicz, M., Saniewska, T., and  
Pernegr, J.

June 1958

Polish Academy of Sciences, Institute of Nuclear  
Research, Warsaw  
NP-6893 (22 pp.)

In interactions of nucleons of cosmic radiation with the nuclei of photographic emulsion (with  $N_h \leq 5$ ) in the limits of energy  $10^{10}$  to  $10^{14}$  ev the angular distributions of secondary particles in the C.M. approximated by gaussian curves show an increase in anisotropy with energy in agreement with the predictions of the Landau theory. It was found, however, that in many high energy jets the angular distribution quite markedly departs from the angular distribution predicted by the theories of Landau and Heisenberg in their present form. This is also reflected in the total differential distribution by a dip in the vicinity of the angle  $\pi/2$  in the C.M. The two-center model that has been introduced by Takagi seems to describe the shape of the angular distribution in the C.M. with better agreement with experiment. In this model it is assumed that the secondary particles are emitted isotropically with the same energy from two centers moving in the C.M. with  $\bar{\gamma}$  considerably less than the  $\gamma$  of the nucleons. The two-centers model permits the factor  $\bar{\gamma}$  of the centers in C.M. to be related to the coefficient of inelasticity, multiplicity, energy of secondary particles in the system of the center, and the energy of the primary nucleon. From this relation and from the observed angular distributions the values of the transversal momentum obtained are in agreement with experiment. (NSA, v. 12, #15,629)

190. STRANGE PARTICLE PRODUCTION IN  
COMPLEX NUCLEI. TECHNICAL REPORT  
NO. 22 [ON] COSMIC RAY AND  
ELEMENTARY PARTICLES GROUP  
Werbrouck, A. E.  
February 20, 1959

# 188. RESEARCH ON COSMIC RAYS—HISTORY AND RESULTS OF RESEARCH ON COSMIC RAYS AT THE COSMIC RAY LABORATORY AT OSAKA UNIVERSITY

Watase, Y., Fukui, S., Higashino, I., Suga, K.,  
Hinotani, K., Mitani, S., Murata, Y., Tanaka, Y., and  
Miyamoto, S.

Annual Report of Scientific Works, Faculty of  
Science, Osaka University, v. 5, pp. 1–49, 1957



Princeton University, Palmer Physical Lab. and  
Naval Ordnance Lab., N. J.  
NP-7306, (99 pp.)  
Nonr-1858(06)

Strange particle production by high-energy pions and protons bombarding carbon, iron, and lead nuclei in a multiplate cloud chamber was investigated. This choice of targets provided an opportunity to compare the effects of multistage processes which are sensitive to nuclear radius. The two stage process that originally motivated the experiment was the indirect production of strange particles by pions in turn produced by a nucleon incident on the same nucleus. Early indications of very low direct production of strange particles by  $p$ - $p$  collisions led to the belief that a large fraction of the production in  $p$ -nucleus collisions was through the indirect process. The value for this fraction in lead is  $\sim 2/3$ . A  $K$ -pair production by protons comparable to the direct production of hyperon- $K$  meson pairs by protons was also observed. To have a quantitative knowledge of the strange particle production by a known pion beam in nuclear matter, the same targets to 1.5 Bev  $\pi$ -mesons as well as 2.8 Bev protons were exposed. This data also yielded interesting comparisons on the effects of other multistage processes, namely the interactions of the strange particles after production. The cross section for the conversion of charged hyperons into neutral hyperons in nuclear interactions seemed to be bigger than geometric. The strange particle production by the pion beam was predominantly direct as shown by a comparison with the bubble chamber studies of  $\pi$ -nucleon collisions. Total cross sections for strange particle production and distributions in lab angle and energy are presented for the observed strange particles. The multiple chamber and its auxiliary equipment are described. An improvement in the stability of the cosmotron proton blow-up beam is explained. As part of the analysis of individual events a least squares fit of measured points to a decay plane is presented in a form suitable for use with a digital computer. (NSA, v. 13, #7949)

**191. THE FLUX OF COSMIC RAY PARTICLES  
WITH  $Z \geq 2$  OVER TEXAS**

Engler, A., Kaplon, M. F., and Klarmann, J.  
1958  
Rochester, University of, New York

NP-6818 (34 pp.)

(See also *Physical Review, The*, v. 112, no. 2, pp.  
597-605, October 15, 1958)

The fluxes of multiply charged cosmic-ray particles have been measured with nuclear emulsions in a high-altitude balloon flight. The identification of  $\alpha$  particles was based on "blob-gap" measurements while those of elements with  $Z \geq 3$  on  $\delta$ -ray densities. The charge resolution obtained was satisfactory. To calculate the fluxes at the top of the atmosphere an extrapolation procedure was employed. Two sets of parameters which account for the interactions in the residual atmosphere, differing considerably as far as their influence on the fluxes of light elements is concerned were used. (NSA, v. 12, #12,477)

**192. SOME CONSIDERATIONS ON THE  
ANALYSIS OF PRIMARY COSMIC RAY  
INTENSITY EXPERIMENTS**

Engler, A., Kaplon, M. F., and Klarmann, J.  
1958

Rochester, University of, New York

NP-7012, (34 pp.)

(See also *Nuovo Cimento, Il*, v. 12, no. 4, pp.  
310-326, May 16, 1959)

A discussion is given of the procedures in the analysis of primary cosmic-ray intensity experiments and the assumptions inherent in their use with particular emphasis on nuclear emulsion as a detector. Explicit formulas for extrapolation of particle intensities for various geometries employed in emulsion work are given. Some discussion of geomagnetic effects is given, and data are presented showing that the Earth's shadow cone is not appreciably present at a geomagnetic latitude of  $40^\circ$ . (NSA, v. 13, #1458)

**193. RADIATIONS IN OUTER SPACE; COSMIC  
AND OTHER RAYS**

Burkhardt, G.

January 1959

Air Force Dept. Air Research and Development  
Command, Washington, D.C.

Bibliography

Books

**194. VIIIth INTERNATIONAL ASTRONAUTICAL  
CONGRESS, BARCELONA, 1957,  
PROCEEDINGS**

Hecht, F., Editor

Springer-Verlag, Vienna, 1958 (612 pp.)

"Study of the Primary Cosmic Radiation by Using Artificial Satellites of the Earth" by Vernov, S. M., Ginzburg, V. L., Kurnosova, I. V., Razorionov, L. A., and Fradkin, M. L. (pp. 464-477) discusses the use of artificial satellites to investigate cosmic ray time variations of different kinds and the charge spectrum of the primary cosmic rays. Investigation of the interaction of cosmic particles with nuclei in the upper atmosphere by the use of satellites is presented. The instruments carried by the satellites are also reported.

#### Periodicals

#### 195. FURTHER STUDIES OF COSMIC RAY BURSTS WITH SOLAR ACTIVITY

Malurkar, S. L.

*Acta Physica Academiae Scientiarum Hungaricae*, Budapest, v. 9, no. 4, pp. 353-368, 1959

Among the upper air observations of cosmic ray intensity, Pomerantz, after a preliminary choice, selected nine instances to relate to solar flares, giving corresponding radio data and reproducing the cosmic ray records. As these were events described in some detail, it was considered desirable to examine them with reference to the evolution of corresponding solar active regions. As the evolution of the region was considered, the use of available solar magnetic data previous and subsequent to the actual flares would not be objectionable. Solar magnetic data were also available for one of the five very large solar flares connected with cosmic ray bursts and allowed good comparison. The examination has not indicated any modification of the conclusions drawn earlier. (PA, v. 62, #7133)

#### 196. THE STUDY OF THE EARTH'S CORPUSCULAR RADIATION AND COSMIC RAYS

Vernov, S. N., Chudakov, A. E., Vakulov, P. V., and Logachev, Iu. I.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 125, no. 2, pp. 304-307, March 1959 (Translated in *Physics Express*, v. 2, no. 5, pp. 1-3, January 1960)

#### 197. THE PART PLAYED BY ANTINUCLEONS AND MESONS IN SECONDARY INTERACTIONS IN THE HIGH-ENERGY RANGE

*Akademii Nauk SSSR, Doklady*, v. 127, no. 1,

pp. 67-69, July 1959 (Abstracted in *Physics Express*, v. 2, no. 6, p. 3, February 1960)

The investigation of the angular distribution of fine tracks in showers recorded in photoemulsions provides a basis for advancing the hypothesis concerning the high degrees of excitation of colliding nucleons which then separately emit  $\pi$ -mesons.

#### 198. 27-DAY PERIOD VARIATIONS OF COSMIC RAY INTENSITY IN THE STRATOSPHERE

Vernov, S. N., Tulinov, V. F., and

Charakhchyan, A. N.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 122, pp. 788-791, October 11, 1958

#### 199. MEASUREMENT OF COSMIC-RAY INTENSITY ON AN ARTIFICIAL EARTH SATELLITE

Vernov, S. N., Grigorov, N. L., Logachev, Yu. I., and Chudakov, A. E.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 120, no. 6, pp. 1231-1233, 1958

Preliminary measurements of cosmic ray intensity, carried out with two independent counters mounted on a satellite, are reported. "Flares" and fluctuations in cosmic ray intensity were recorded. For example, a 50 percent increase in cosmic ray intensity occurred at latitudes above 58 deg on November 7, 1957. During these measurements the satellite was 225-240 km above the Earth's surface. (PA, v. 62, #1566)

#### 200. A STUDY OF EXTENSIVE AIR SHOWERS OF THE COSMIC RADIATION

Dovzhenko, O., Zatselin, V., Murzina, E.,

Nikolskii, S., Rakobolskaya, I., and Tukish, E.

*Akademii Nauk SSSR, Doklady* (in Russian), v. 118, no. 5, pp. 899-902, 1958

Detailed results are presented of a study of the energy characteristics of extensive showers using large counter arrays at 3860 m above sea-level in conjunction with (a) counter arrays vertically below at depths of 800 and 1600 g/cm<sup>2</sup> of water equivalent, and (b) a multiplate

cloud chamber and ionization chamber assemblies. With arrangement (a), it was found: (1) the energy spectrum of  $\mu$ -mesons at a distance of  $\leq 10$  m from the shower axis followed  $E^{-0.27 \pm 0.06}$  law for energies  $1.5 \leq E \leq 3.5$  Bev, and (2) the cross-section of the core of showers with primary energy greater than  $6 \times 10^{14}$  ev was 1–2 m. With arrangement (b) it was found the  $\pi^0$ -mesons of energy  $\leq 10^{10}$  ev made a significant contribution to the electron-photon cascade. The distribution of energy between the hard and soft components was determined as a function of distance from the shower axis. (PA, v. 61, #4098)

## 201. INTERACTIONS OF HIGH ENERGY PARTICLES WITH NUCLEI

Zhdanov, A. P., Berkovich, I. B., et al.

*Akademii Nauk SSSR, Doklady* (in Russian),  
v. 115, pp. 1093–1096, August 21, 1957

The mechanism of the elementary particle production in nucleon-nuclei interactions in the energy range  $10^{11}$  to  $10^{13}$  ev was investigated. Data are given on the studies made with seven shower streams with a relatively large number of shower particles, formed during the nucleon interactions with nuclei in emulsions irradiated for 7 hr and 30 km elevation. The selected streams formed by neutral and charged particles were divided into two groups, one group having a narrow cone and symmetric integral distributions and the second having a considerably larger cone and larger number of charged particles. Diagrams are given of the angular distribution of shower particles in spallations of the investigated streams. (NSA, v. 12, #2379)

## 202. THE INTERACTION OF COSMIC RAY PROTONS AT ABOUT $10^{10}$ ev WITH Pb NUCLEI

Baradzei, L. T., Rubtsov, V. I., et al.

*Akademii Nauk SSSR, Doklady* (in Russian),  
v. 115, pp. 685–688, August 1, 1957

Investigations were performed at 9000 m elevation in a Wilson chamber placed in a magnetic field of 9200 oersted. To exclude interactions induced by mesons, 38 electron-nuclear showers generated in a Pb plate by single charged particles were selected. Measurements were taken of spatial particle track distributions, of charged particle pulses, and of their ionization ability.

The estimate of particle direction was determined within  $\sim 2$  deg. The ionizing ability was determined visually. Diagrams are given of the energy distribution of particles (electrons,  $\pi$  + mesons, and heavier particles) emitted during nuclear interactions in Pb. The energy values of primary particles, evaluated from the magnitude of the shower-forming particle flux, and the multiplicity and angular distribution of shower particles, were from 10 to 13 Bev. Hence, it has been found in the interactions with Pb nucleus that the proton at about 10 Bev suffers a mean loss of about  $\frac{1}{3}$  to  $\frac{1}{2}$  of its energy, the charged and neutral  $\pi$ -mesons carry away  $\frac{1}{3}$  of the proton energy, and approximately the same amount is carried away by heavier particles. (NSA, v. 12, #1458)

## 203. DETERMINATION OF THE FLUX OF THE PRIMARY COSMIC PARTICLES AT $31^\circ$ N LATITUDE

Alekseeva, K. I., Brikker, S. I., et al.

*Akademii Nauk SSSR, Doklady* (in Russian),  
v. 115, pp. 71–74, July 1, 1957

The intensity of the hard component in the stratosphere was measured during the determination of the cross section for the inelastic interaction of cosmic ray particles with carbon and hydrogen nuclei. The measurements permitted the determination of the flux of the primary particles at the atmosphere boundary. Descriptions are given of the instruments used for the measurements of the inelastic interaction and of the results obtained in measuring the intensity of the hard component; however, the results of the cross section measurements will be published later. The absorption range of the charged particles of the shower-forming component in the stratosphere at the  $31^\circ$ N latitude was found to be 150 to 170 g/cm<sup>2</sup>. (NSA, v. 12, #338)

## 204. RESULTS OF OBSERVATIONS OF DISCRETE SOURCES OF COSMIC RADIATION AT 3.2 cm WAVELENGTH

Kaidanovski, N. L., Shklovski, I. S., et al.

April 19, 1955

*Akademii Nauk SSSR, Doklady*, v. 104, pp. 517–519, 1955

Translations

RT-3545

**205. CONCERNING STABLE PARTICLES WITH MASS GREATER THAN THAT OF A PROTON IN COSMIC RADIATION AT AN ALTITUDE OF 3,250 METERS ABOVE SEA LEVEL**

Dayon, M. I.

(AEC-tr-2416) Translated by M. Hamermesh from *Akademii Nauk SSSR, Doklady*, v. 101, pp. 821-823, 1955

Measurements of the mass spectra of particles of cosmic radiation were made with a magnetic spectrometer in which the detection equipment is replaced by a large rectangular Wilson chamber. From the spectrum obtained of ionizing events, 19 particles from a total of 267 were observed whose mass corresponded to that of the deuteron. In the same series of measurements 104 non-ionizing stoppings of particles were seen. From the spectrum it was determined that 19 deuterons and 31 anomalous protons were recorded. (NSA, v. 12, #6665)

**206. PHOTOFISSION OF HEAVY COSMIC RAY PARTICLES OCCURRING UNDER THE ACTION OF SOLAR RADIATION (O FOTORASSHCHEPLENII TIAZHELYKH CHASTITS KOSMICHESKIKH LUCHEI, PROISKHODIASHCHEM POD VLIANIEM SOLNECHNOGO IZLUCHENIIA)**

Zatsepin, G. T.

(TT-717) Translated by G. Belkov from *Akademii Nauk SSSR, Doklady*, v. 80, pp. 577-578, 1951

**207. ON LIMITING EXTENSIVE ATMOSPHERIC SHOWERS OF COSMIC RADIATION**

Skobel'tsyn, D. V.

*Akademii Nauk SSSR, Doklady*, v. 67, no. 1, pp. 45-48, 1949

Abstracted in *Technical Translations*, v. 2, no. 9, p. 623, November 6, 1959

**208. INTERNATIONAL CONFERENCE ON COSMIC RAYS**

Dobrotin, N. A.

*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk* (in Russian), v. 69, no. 4, pp. 679-691, December 1959

**209. INVESTIGATION OF VARIATIONS IN COSMIC RADIATION**

Vernov, S. N., Logachev, Y. I., Chudakov, A. E., and Shafer, Y. G.

*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk*, v. 63, no. 1b, September 1957

**210. INVESTIGATION OF THE COMPOSITION OF PRIMARY COSMIC RAYS**

Vernov, S. N., Ginzburg, V. L., Kurnosova, L. V., Razorenov, L. A., and Fradkin, M. I.

*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk*, (in Russian) v. 63, no. 1a-1b, pp. 131-148, 1957

This review article is largely concerned with the value of an artificial Earth satellite as a means to taking observations on the energy spectrum of high-energy particles. A table summarizing current information on the  $\alpha$ -particle stream in primary cosmic radiation is given. (48 ref.) (PA, v. 61, #6015)

**211. VARIATIONS IN COSMIC RAYS**

Dorman, L. I. and Feinberg, E. L.

*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk*, (in Russian) v. 59, no. 2, pp. 189-228, 1958

Current experimental information is summarized excellently in tabular form, showing, for latitudes 0° and 50° N, the variations of hard component, neutron content, ionizing component etc., under the following conditions: seasonal, daily, semi-diurnal, yearly, 11-yearly, 27-day, magnetic storm, major and minor solar protuberance, etc. Also discussed are such problems as the correlation of variations with various astrophysical phenomena, and the origin of cosmic rays. (55 ref) (PA, v. 61, #6023)

**212. COSMIC RAY PROGRAM: FIRST TWELVE MONTHS**

Forbush, S. E.

*American Geophysical Union, Transactions*, v. 39, no. 5, pp. 1004-1010, October 1958

This report is based on a summary of results in the IGY Cosmic Ray Program prepared by S. E. Forbush, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

213. NEW DATA ON THE CHEMICAL COMPOSITION OF COSMIC RAYS  
Ginsburg, V. and Razoryonov, L.  
*American Scientist*, v. 47, no. 4, pp. 562–566,  
December 1959

214. LES PREBAISSES DE RAYONS COSMIQUE EN PERIODES DE MAXIMUM DE L'ACTIVITE SOLAIRE, AVRIL 1957–DECEMBRE 1958 (THE PREDECREASE OF THE COSMIC RAYS IN PERIODS OF MAXIMUM SOLAR ACTIVITY, APRIL 1957–DECEMBER 1958)  
Legrand, J. P.  
*Annales de Geophysique*, France, v. 16, no. 1, pp. 140–142, January–March 1960

The cosmic radiation predecrease event displayed during the continuous measurements carried out in the course of the International Geophysical Year, revealed the presence of particularly active sunspots happening on the east limb of the Sun. The author gives a description of this event accompanied by several examples of correlations, and a short insight into the way they originate.

215. THE DURATION OF THE EMISSION AND THE GRADIENT OF THE IMPULSE SPECTRUM OF THE SOLAR COSMIC RAYS DURING THE CHROMOSPHERIC ERUPTION OF 23/2/1956  
Pfozter, G.  
*Annalen der Physik*, Leipzig, (in German), v. 20, no. 1–6, pp. 26–41, 1957

Recorded data on neutrons have been used to determine the direct radiation to Earth, and the retarded radiation stored during up to 16 hours in the solar system. Taking a spectrum  $f(p)dp \sim p^{-\gamma}$ , the exponent  $\gamma \cong 3.4$  can be taken for the impulse range  $2 \leq p \leq 6$  Bev/c. For the stored radiation  $5.5 \leq \gamma \leq 7$  according to Meyer (PA, v. 60, #2387), showing the loss in radiation in the storage process. (PA, v. 62, #4761)

216. STUDY OF THE NUCLEONIC COMPONENT OF COSMIC RADIATION RECORDED IN EMULSIONS WHOSE DIRECTION WAS FIXED WITH RESPECT TO THE SOLAR SYSTEM  
Desprez, S.  
*Annales de physique*, Paris (in French), Series 13, v. 3, no. 3–4, pp. 230–257, March–April, 1958

No variation was found, within the statistical limits, in the directional distribution with respect to the Sun, of 3563 tracks recorded in nuclear emulsions exposed at 1912 m above sea-level. (PA, v. 61, #8085)

217. THE LATITUDE EFFECT OF THE COSMIC RAY NUCLEONIC COMPONENT IN RELATION TO THE MAGNETIC DIP  
Sandstrom, A. E.  
*Arkiv för Physik*, v. 14, Paper 25, pp. 409–418, 1958

Concerned with data collected by means of an airborne monitor during a flight across the north polar region and around Asia and Europe. The cosmic ray intensity values have been normalized by means of the monitors in Uppsala and on Mt. Norikura and Zugspitze. The difference between the three sets of normalized values turn out to be comparatively unimportant. The latitude effect is studied as a function of the dip. Some discrepancies are discussed as well as the influence of a possible longitude effect. By comparing the geographical coordinates of points of equal cosmic ray intensity it is demonstrated that the effective field causing the latitude effect cannot easily be represented by a simple dipole model. Instead the true geomagnetic field, as represented by the dip, appears to be a good first approximation of the field determining the cutoff of the primaries. Anomalies can be ascribed to the fact that the tracks of the primaries, from being at first determined by a dipole field, gradually enter a part of the geomagnetic field differing very little from that at the surface of the Earth. (PA, v. 62, #4765)

218. THE COSMIC RAY PHOTON AND  $\pi^0$ -MESON ENERGY SPECTRA AT 29–30 km ABOVE SEA-LEVEL  
Svensson, G.  
*Arkiv för Physik*, v. 13, Paper 28, pp. 347–368, 1958

The photon spectrum at 29–30 km above sea-level and  $64^\circ$ – $65^\circ$  geomagnetic latitude was determined by means

of the nuclear emulsion technique, the multiple scattering of the electron-pairs, produced when the photons materialize in the emulsion, being measured. Distortion, noise, energy loss of the electrons, outscattering and materialization probability were taken into account. The relation between the recorded photon spectrum and the  $\pi^0$ -meson spectrum was studied. The exponent obtained for the differential energy spectrum of the  $\pi^0$ -mesons is  $1.5 \pm 0.2$  in the total energy interval from 0.25 Bev to 3 Bev and  $2.8 \pm 0.4$  for energies greater than 3 Bev. The last exponent may suffer from systematic errors due distortion, spurious scattering and scanning efficiency, which are difficult to estimate. (PA, v. 61, #7144)

**219. ON THE INTERPRETATION OF SUDDEN DECREASES IN COSMIC RAYS FROM THE SUN**

Tandberg-Hanssen, E.

*Astrophysica Norvegica*, v. 5, no. 9, pp. 241–258, September 1956

The changes in cosmic ray intensity (CRI)—especially short-lived intensity decreases—and their relation to solar activity were investigated. The following results were obtained: (1) The active regions responsible for short-lived decreases in cosmic ray intensity are not necessarily associated with sunspots, or flares or unipolar magnetic (UM) regions. They may have other characteristics than the active regions responsible for CRI increases. (2) There is no one-to-one correlation between CRI decreases and magnetic storms. Recurrent storms with gradual commencement often occur simultaneously with CRI decreases, and also series of storms with sudden commencement coincide with CRI decreases. (3) The investigation supports the view that cosmic ray emission is a normal quiet-Sun quality. (4) CRI decreases are thought to be caused by a shielding process taking place in ejected clouds of ionized gas pervaded by magnetic fields. (PA, v. 61, #7157)

**220. THE SOLAR DAILY VARIATION OF COSMIC RAY MESON INTENSITY AT  $\lambda = 52^\circ\text{S}$  AND  $\lambda = 73^\circ\text{S}$**

Parsons, N. R.

*Australian Journal of Physics*, v. 10, no. 3, pp. 387–396, September 1957

Some preliminary results are given of an investigation of solar daily variations recorded by vertically directed meson telescopes at Hobart, Tasmania (geomagnetic latitude  $\lambda = 52^\circ\text{S}$ ) and at Mawson, Antarctica ( $\lambda = 73^\circ\text{S}$ ). Long-term trends in phase of the variation are found to be similar to those reported by observers in the northern hemisphere. However, a substantial and fairly consistent phase difference in local time is apparent between the two stations, and its origin is discussed. A brief discussion of pressure-correction procedures is also given. (PA, v. 61, #5093)

**221. DIRECTIONAL MEASUREMENTS OF THE DAILY VARIATION OF COSMIC RAY MESON INTENSITY AT  $\lambda = 73^\circ\text{S}$**

Parsons, N. R.

*Australian Journal of Physics*, v. 10, pp. 462–470, December 1957

Measurements are reported of the daily variations of meson intensity at Mawson, Antarctica ( $\lambda = 73^\circ\text{S}$ ), recorded by counter telescopes inclined at  $45^\circ$  to the vertical in each of north, east, south, and west directions. The results, together with those from a vertical telescope, are examined and found to be inconsistent with an assumed common origin of the different directional variations in the interaction of an anisotropic primary radiation with the Earth's dipole field. (NSA, v. 12, #6020)

**222. PIONEER V DEEP SPACE REPORTS PARALLEL EARLIER RADIATION DATA**

*Aviation Week and Space Technology*, v. 72, no. 13, p. 32, March 28, 1960

*Pioneer V* probe is returning deep-space data from its cosmic ray experiments which appear to confirm the radiation picture predicted from earlier measurements made beyond the Van Allen belts.

**223. THE COSMIC RAY INCREASE OF 17 JULY 1959**

Bailey, D. K. and Pomerantz, M. A.

*Canadian Journal of Physics*, v. 38, no. 2, pp. 332–333, February 1960

Evidence is presented that the Sun emitted particles of cosmic ray energy during the period of cosmic ray increase. This corresponded to the great solar flare of July 16, 1959.

**224. THE UNUSUAL COSMIC RAY EVENTS  
OF JULY 17-18, 1959**

Pomerantz, M. A., Rose, D. C., and Wilson, B. G.  
*Canadian Journal of Physics*, v. 38, no. 2,  
pp. 328-331, February 1960

Differences are noted in the intensity changes with different geographical positions and altitudes.

**225. TRANSIENT DECREASES IN COSMIC RAY  
INTENSITY DURING THE PERIOD  
OCTOBER 1956 TO JANUARY 1958**

Fenton, A. G., McCracken, K. G., Rose, D. C., and  
Wilson, B. G.  
*Canadian Journal of Physics*, v. 37, no. 5,  
pp. 569-578, May 1959

Recent nucleon intensity data obtained from high counting rate recorders at Ottawa and Hobart and subsidiary stations, have been examined for evidence for the superposition of transient decreases. It is concluded that, with the statistical accuracy now available due to the high counting rates, it is possible to distinguish two types of transient decrease in the observed variations, superimposed upon the slower 11-year intensity changes. One of these is an almost symmetrical event lasting up to two weeks and exhibiting a recurrence tendency of about 27 days, while the other is the more abrupt Forbush decrease which recovers over a period of several days. The evidence indicates that the intensity-controlling mechanism responsible for these short-term transient changes is able to influence the cosmic ray flux at the Earth independently of other events that may be in progress at the time. There is also evidence that the physical process controlling the Forbush type of decrease operates over a volume large compared with the Earth because the intensity changes at places as far apart as Ottawa, Canada, and Hobart, Tasmania, show changes that are the same within the accuracy of the measurements. (PA, v. 62, #7138)

**226. ATMOSPHERIC EFFECTS ON COSMIC RAY  
INTENSITY AT SEA LEVEL**

Mathews, P. M.  
*Canadian Journal of Physics*, v. 37, no. 2,  
pp. 85-101, February 1959

Cosmic ray intensity variations of primary origin and those caused by meteorological changes appear superposed in records obtained from meson counter telescopes

and neutron monitors at sea level. The study of either of these types of variation is thus greatly complicated by the other. In the present work, the step is taken of processing the raw data to eliminate primary variations (and the inherent statistical fluctuations) so as to make possible a direct comparison of the remaining variations with the changes in atmospheric variables over the same period. The subsequent analysis confirms the expectation that there are no appreciable atmospheric effects on the intensity of the nucleonic component beyond the well-known effect associated with the sea level barometric pressure  $B$ . But in the meson case there is strong evidence that the widely used set of variables  $H_{100}$ ,  $T_{100}$  (the height and temperature of the 100 mb level) and  $B$  is not very suitable for representing atmospheric effects; it seems essential to include a variable representing temperatures in the lower part of the atmosphere, and the set of variables  $T_{800}$  (temperature of the 800 mb layer),  $H_{100}$ , and  $B$ , with coefficients  $k_T = -0.082 \pm 0.008\%$  per deg C,  $k_H = -3.04 \pm 0.61\%/km$ , and  $k_B = -0.134 \pm 0.004\%/mb$  appears to be the best. The theoretical formula of Dorman (1957) with a barometric coefficient  $\beta = -0.147 \pm 0.004\%/mb$  and with the term representing the "temperature effect" reduced by a factor  $0.76 \pm 0.03$ , gives slightly better results. However, the improvement, at least in the case of the data analyzed is too small to justify the great labor involved in using this formula. (PA, v. 62, #4766)

**227. THE VARIATION OF SEA LEVEL COSMIC  
RAY INTENSITY BETWEEN 1954 AND 1957**

Fenton, A. G., Fenton, K. B., and Rose, D. C.  
*Canadian Journal of Physics*, v. 36, no. 7,  
pp. 824-839, July 1958

Results from neutron monitors and meson telescopes at Ottawa (geomagnetic latitude  $57^\circ N$ ) and Resolute (geomagnetic latitude  $83^\circ N$ ) are presented for the years 1954-1957, a period of increasing solar activity. The results indicate that the sea level meson intensity at these latitudes decreased by 5-6 percent between April 1954 and December 1957. During the same period the intensity of the nucleonic component at these stations decreased by over 22 per cent. Investigation of the relative response of the two types of recorder to transient decreases during this period indicates that the long-term change in the intensity level cannot be explained completely as an accumulation of shorter transient decreases,

which become more frequent at times of high solar activity. It is concluded that the transient decreases are superimposed upon the longer term changes, each being produced by a separate modulation process but ultimately controlled by the general level of solar activity. Significant differences are found in the shape of transient decreases observed at the Canadian stations, both between different components at the one station and the same component at different stations. These may be interpreted as due to a varying energy dependence from one transient decrease to another, and to anisotropy in the primary cosmic radiation at these times. (PA, v. 61, #8095)

**228. A COSMIC RAY INCREASE RELATED TO SOLAR ACTIVITY**

Katzman, J.

*Canadian Journal of Physics*, v. 36, pp. 807-814, July 1958

An increase in the intensity of cosmic ray particles of minimum momentum at Ottawa, Canada, of  $4.5 \times 10^9$  ev/c was observed with telescopes of solid angles  $11.5 \times 10^{-4}$  and  $26.0 \times 10^{-4}$  steradians with increase of solar activity. A large increase in cosmic ray activity for the period September 1956 to February 1957 was observed to accompany a large and sustained increase in solar activity as determined by means of the critical frequency of the F-2 layer. (NSA, v. 12, #13,210)

**229. COSMIC RAY INTENSITY VARIATIONS AT SEA LEVEL DURING MAGNETIC-STORM PERIODS**

Ramaswamy, G. and Chatterjee, S. D.

*Canadian Journal of Physics*, v. 36, pp. 635-637, May 1958

Some geophysical aspects of cosmic radiation in the light of ion chamber measurements taken at Ottawa during February-May, 1951 are discussed. A curve, percent deviation from pre-storm average plotted against time, shows a general irregular pattern in variations. Cosmic ray intensity decreases, immediately after the commencement of magnetic storms, are observable. These decreases are not within the general pattern of variations and are therefore physically real. The simultaneous decreases might be explained as being due to the mag-

netic storms. No theory has been conducted to successfully explain the behavior of cosmic ray intensity during magnetic storms. (NSA, v. 12, #9890)

**230. THE POSSIBILITY OF PREDICTIONS OF SOLAR PHENOMENA AND THEIR REPERCUSSIONS ON THE EARTH BY STUDYING COSMIC RAY INTENSITY**

Legrand, J.-P.

*Comptes rendus hebdomadaires des séances de l'académie des sciences*, (in French), v. 247, pp. 70-73, July 7, 1958

Several cosmic radiation storms were observed during the period from April 12, 1957, to March 31, 1958, a time when the intensity of cosmic radiation was being constantly monitored. The cosmic storms were preceded by a decrease in the level of cosmic intensity of the order of 1 to 3 percent with respect to the normal level. This decrease, which was called the "beginning of the pre-decline," preceded from 24 to 48 hours the chromospheric eruptions which are followed by geomagnetic and ionospheric disturbances. It appears possible that this "beginning of the predecline" could be used to predict solar phenomena and their repercussions on the Earth. (NSA, v. 12, #14,047)

**231. BALLOON FLIGHT INVESTIGATIONS OF PRIMARY COSMIC RAYS DURING SOLAR DISTURBANCES**

Pomerantz, M. A., Agarwal, S. P., and Potnis, V. R.

*Franklin Institute, Journal of the*, v. 269, no. 3, pp. 235-244, March 1960

An extensive series of balloon flights was conducted during the peak of the present solar maximum, utilizing instruments identical with those which had been flown previously during the declining portion of the preceding solar cycle (1949-1952).

**232. DIRECT OBSERVATION OF PERIODIC VARIATION OF PRIMARY COSMIC RAY INTENSITY**

Pomerantz, M. A., Agarwal, S. P., and Potnis, V. R.

*Franklin Institute, Journal of the*, v. 265, no. 1, pp. 67-68, January 1958



**233. NUCLEAR DISINTEGRATIONS PRODUCED IN NUCLEAR EMULSIONS BY  $\alpha$ -PARTICLES OF GREAT ENERGY**

Appa Rao, M. V. K., Daniel, R. R., and Neelakantan, K. A.

*Indian Academy of Sciences, Proceedings of the, Section A43, pp. 181-201, 1956*

A study of nuclear disintegrations caused by  $\alpha$  particles of primary cosmic radiation with energies  $> 5$  Bev per nucleon has been carried out. In a systematic survey in nuclear emulsions using "along the track" scanning method, 479  $\alpha$  particles with a total track length of 40.84 meters and 242 interactions were obtained. From the angular distribution of shower particles associated with these interactions, a procedure has been found for distinguishing protons, which originally formed part of the incident  $\alpha$  particle and which have not taken part in the interaction, from other charged particles. The mean free path for nuclear interaction in G-5 emulsion is found to be  $17.5 \pm 1.1$  cm ( $68.9 \pm 4.3$  gm/cm<sup>2</sup>). Assigning both to the incident  $\alpha$  particle and to the target nuclei a radius  $R = r_0 A^{1/3}$ , one obtains an effective nuclear radius  $r_0 = 1.13 \pm 0.04 \times 10^{-13}$  cm. Using the number of protons emerging from disintegrations of heavy nuclei (Silver and Bromine) without having participated in the interaction (as can be deduced from the angular distribution) and assuming spherical nuclei of uniform density, the mean free path of nucleons in nuclear matter is calculated to be less than  $3.2 \times 10^{-13}$  cm. (NSA, v. 12, #2991)

**234. A STUDY ON THE COSMIC RAY NUCLEAR INTERACTIONS IN LEAD AT 9000 FT**

Mathur, R. N. and Gill, P. S.

*Indian Journal of Physics, v. 32, pp. 19-25, January 1958*

Nuclear disintegration rates in lead plates of different thicknesses have been studied under no absorber and under 280 g/cm<sup>2</sup> of lead absorbers. The transition phenomena are exhibited by both the unfiltered and filtered  $N$  radiation. A comparative study, however, reveals a change in the characteristics of the  $N$  radiation when filtered through the absorber. Unfiltered  $N$  radiation shows a broad maximum around 25 g/cm<sup>2</sup> of Pb. For filtered  $N$  radiation, however, there appears to be an upward shift in the position of the maximum. The interaction mean free path of the unfiltered  $N$  radiation is

obtained equal to 200 g/cm<sup>2</sup> of lead. Filtered  $N$  radiation, however, seems to have an interaction mean free path greater than 250 g/cm<sup>2</sup> of lead. The absorption mean free path of the  $N$  radiation is obtained as 340 g/cm<sup>2</sup> of lead. (NSA, v. 12, #6667)

**235. MOMENTUM SPECTRUM OF DEUTERONS IN THE VERTICAL COSMIC RAY FLUX**

Ayvazyan, M. L.

*Izvestiya Akademii Nauk Armyanskoi SSR, Fiziko-Matematicheskie, Estestvenye i Technicheskie Nauki, v. 9, no. 3, pp. 91-101, 1956*  
(Translated from *Referativnyi Zhurnal: Fizika, no. 4, 1957*)

By use of a magnetic mass spectrometer and a double proportional counter, a determination was made of the number of deuterons in the flux of cosmic rays at an altitude of 3200 meters in the momentum range from 0.7 to 1.7 Bev/c, under a lead filter 32 g/cm<sup>2</sup> thick. The spectrum obtained has a sharp maximum at approximately 1.2 Bev/c, and the maximum deuteron flux is  $0.75 \pm 0.14$  cm<sup>-2</sup> sec<sup>-1</sup> steradian<sup>-1</sup> (Bev/c)<sup>-1</sup>. (NSA, v. 12, #13,212)

**236. WORLD-WIDE DISTRIBUTION OF COSMIC RAY NEUTRON INTENSITY AT SEA LEVEL**

Kodama, M.

*Journal of Geomagnetism and Geoelectricity, v. 10, no. 2, pp. 37-46, 1959*

The distribution was mapped from an analysis of eight latitude surveys carried out between 1937 and 1957. The contour map thus obtained was compared with the various models for the Earth's geomagnetic field. (PA, v. 62, #7139)

**237. THE INFLUENCE OF MODULATION EFFECTS ON SOLAR FLARE RADIATION**

Brown, R. R.

*Journal of Geomagnetism and Geoelectricity, v. 10, no. 1, pp. 1-6, 1958*

The modulation of cosmic rays during the February 23, 1956 solar flare cosmic ray outburst is estimated from the latitude variation of the cosmic ray intensity decrease observed in the period about the flare event. The perturbing influence of these modulation effects on the rigidity

spectrum of the flare radiation is calculated. The change in the slope of the rigidity spectrum is found to be small, as the modulation function does not have a strong dependence on rigidity between low and middle magnetic latitudes. (PA, v. 62, #5862)

**238. SOLAR ACTIVITY AND COSMIC RADIATION**

Brown, R. R.

*Journal of Geomagnetism and Geoelectricity*,  
v. 9, no. 2, pp. 79-85, 1957

Observations on the correlation of solar activity with cosmic radiation are reported. The relation of these results to models involving solar corpuscular streams is briefly considered. (PA, v. 62, #383)

**239. DIURNAL VARIATION OF VERTICAL COSMIC RAYS—NARROW TOTAL AND HIGH ENERGY COMPONENTS**

Yagi, T. and Ueno, H.

*Journal of Geomagnetism and Geoelectricity*,  
v. 8, no. 3, pp. 93-107, September 1956

**240. ELEVEN YEAR VARIATION OF COSMIC-RAY DISTURBANCE AND ITS RELATION TO SOLAR AND GEOMAGNETIC ACTIVITIES**

Miyazaki, Y. and Wada, M.

*Journal of Geomagnetism and Geoelectricity*,  
v. 7, no. 1-2, pp. 1-8, June 1955

**241. THE DIURNAL VARIATION OF COSMIC RAYS**

Nagashima, K.

*Journal of Geomagnetism and Geoelectricity*,  
v. 7, no. 1-2, pp. 51-68, June 1955

The energy gain or loss of the primary cosmic ray produced by an electromagnetic field of a solar stream is examined, and the diurnal variation of cosmic rays during magnetic storms explained by this energy variation theory. The amplitudes and the times of the maximum intensity of the diurnal variations are calculated at various altitudes and latitudes. (PA, v. 62, #381)

**242. RADIOISOTOPES  $P^{32}$ ,  $Be^7$ , AND  $S^{35}$  IN THE ATMOSPHERE**

Lal, D., Rama, and Zutshi, P. K.

*Journal of Geophysical Research*, v. 65, no. 2,  
pp. 669-674, February 1960

The concentrations of several cosmic-ray-produced radioisotopes were measured.

**243. LOW-ENERGY COSMIC RAY EVENTS ASSOCIATED WITH SOLAR FLARES**

Reid, G. C. and Leinbach, H.

*Journal of Geophysical Research*, v. 64, no. 11,  
pp. 1801-1805, November 1959

**244. COSMIC RAY MEASUREMENTS IN THE VICINITY OF PLANETS AND SOME APPLICATIONS. PART I**

Singer, S. F. and Wentworth, R. C.

*Journal of Geophysical Research*, v. 64, no. 11,  
pp. 1807-1813, November 1959

**245. A COMPARISON OF THE COSMIC RAY INTENSITY AT HIGH ALTITUDES WITH THE NUCLEONIC COMPONENT AT GROUND ELEVATION**

Henkel, J. E., Lockwood, J. A., and Trainor, J. H.

*Journal of Geophysical Research*, v. 64, no. 10,  
pp. 1427-1438, October 1959

A series of balloon-borne soundings in the atmosphere with single Geiger tubes has been made during the period January to September 1958. The counting rate determined at the Pfofzer maximum is compared with that recorded by the nucleonic detector at Mt. Washington (1909 m;  $\lambda = 55^\circ N$ ). Large changes in the counting rate of each detector were observed, and the ratio of these changes is 2-1. Several large deviations from this normal ratio were also observed; they occur for flights on which the shape of the intensity-altitude curve near the Pfofzer maximum is quite different from normal. The changes are explained either in terms of depressions of the low-energy portion of the cosmic ray spectrum following marked decreases in the nucleonic component or by the presence of excess low-energy radiation. An anomalous increase of  $\sim 100$  percent observed at high altitudes during one flight is attributed to high-energy X-radiation. It is found that the

hemispherical average unidirectional intensity above the atmosphere derived from the counting rate at the Pfozter maximum has decreased 200 percent from 1954 to 1958 at  $\lambda = 53^\circ$  N, and this change is compared with results at other latitudes.

**246. OBSERVATIONS OF LOW-ENERGY SOLAR COSMIC RAYS FROM THE FLARE OF 22 AUGUST 1958**

Anderson, K. A., Arnoldy, R., Hoffman, R., Peterson, L., and Winckler, J. R.  
*Journal of Geophysical Research*, v. 64, no. 9, pp. 1133–1147, September 1959

**247. IONIZING RADIATION AT ALTITUDES OF 3,500 TO 36,000 KILOMETERS. PIONEER I**

Rosen, A., Senett, C. P., Coleman, P. J., Jr., and McIlwain, C. E.  
*Journal of Geophysical Research*, v. 64, pp. 709–712, July 1959

The total ionizing component of cosmic radiation was measured on October 11, 1958, by means of an ionization chamber mounted on the *Pioneer I* lunar probe vehicle. Data were taken over an altitude range of 3,500 to 26,000 km and a latitude range of  $35^\circ$ N to  $5^\circ$ N. The calibration procedure and the analysis of the telemetered data are described. (NSA, v. 13, #17,100)

**248. BALLOON OBSERVATIONS OF SOLAR COSMIC RAYS ON MARCH 26, 1958**

Freier, P. S., Ney, E. P., and Winckler, J. R.  
*Journal of Geophysical Research*, v. 64, no. 6, pp. 685–688, June 1959

**249. SOLAR ACTIVITY AND TRANSIENT DECREASES IN COSMIC RAY INTENSITY**  
Venkatesan, D.

*Journal of Geophysical Research*, v. 64, no. 5, pp. 505–520, May 1959

**250. EXCESS RADIATION AT THE PFOTZER MAXIMUM DURING GEOPHYSICAL DISTURBANCES**

Brown, R. R.  
*Journal of Geophysical Research*, v. 64, no. 3, pp. 323–329, March 1959

The Pfozter maximum is  $\sim 50$  gm/cm<sup>2</sup> atmospheric depth. Investigations reveal temporary presence of excess radiation at a latitude well below the auroral zone.

**251. PROGRESS IN COSMIC RAY RESEARCH SINCE 1947**

Peters, B.

*Journal of Geophysical Research*, v. 64, pp. 155–173, February 1959

Cosmic ray physics, which ten years ago was a fairly specialized branch of science, has in the course of its recent development become closely linked with many other fields of research. It has become an integral part of astrophysics, radioastronomy, and solar physics; it has made important contributions to such diverse fields as geomagnetism, hydrology, and archeology, and has begun to gain some importance in the study of meteorites and of oceanography and meteorology. It has also given rise to one of the newest and most active branches of physics, "particle physics", and has thereby provided the impetus for designing the large and powerful particle accelerators which are now in operation or under construction in various parts of the world. This paper is a survey of the most important developments which have taken place in cosmic ray physics during the last decade. The principal technical advances which have exerted decisive influence on cosmic ray research are the development of large stratosphere balloons, of nuclear emulsions, and of radio telescopes, as well as the great progress made since the war in radio chemistry and in low level beta- and gamma-ray counting.

The three sections following the introduction discuss how, with the help of these and others techniques, the nature of the primary cosmic ray particles was determined and how a connection was established between cosmic ray effects and astrophysical and solar phenomena. The next section deals with largely successful efforts which have been made to understand the complicated chain of processes by which the energy carried by the primary cosmic ray particles entering from outer space is first distributed over a great variety of new stable and unstable particles and finally is dissipated within the atmosphere. The two following sections treat the discovery of stable and radioactive isotopes which are produced during the passage of cosmic radiation through the atmosphere and contain a short review of the application which these isotopes have found in other branches of science. The last

section contains a brief discussion of still unsolved problems which have now become accessible because of more recent technical advances such as satellites, permanent polar stations, and synoptic cosmic ray observations during the International Geophysical Year. (NSA, v. 13, #10,199)

**252. COSMIC-RAY INTENSITY VARIATIONS DURING TWO SOLAR CYCLES**

Forbush, S. E.

*Journal of Geophysical Research*, v. 63, no. 4, pp. 651-669, December 1958

An improved correction for instrumental drift at Huancayo is derived and the reliability of the corrections for seasonal variations is discussed. From ionization chambers, the decrease of intensity from its maxima (near sunspot minima) is shown to lag a year or more behind the increase of solar activity following sunspot minima. This lag does not appear in the results obtained by Neher at high altitude and high latitude, nor in those obtained by Rose from a neutron monitor at Ottawa. The variability of daily means of cosmic ray intensity (from monthly means) is in 1957 the largest observed during two complete solar cycles. Tables of monthly means corrected for seasonal wave are included, together with graphs of daily means at Huancayo for the period 1954-1957. (PA, v. 62, #3618)

**253. OCCURRENCE OF SOFT RADIATION DURING THE MAGNETIC STORM OF 29 AUGUST 1957**

Anderson, K. A.

*Journal of Geophysical Research*, v. 62, no. 4, pp. 641-644, December 1957

The time sequence of events as recorded at Fort Churchill, Canada, before and during the intense magnetic storm are outlined. Cosmic ray measurements made in a balloon indicated a rapid increase in amplitude about 20 min before the time of commencement of the storm, and it is suggested that this extra-radiation at high altitude may be X-rays of energy  $< 700$  kev, produced by the acceleration of electrons within a few Earth radii of the Earth's surface. (PA, v. 61, #6020)

**254. THE SUPERPOSITION OF COSMIC-RAY EFFECTS ON FEBRUARY 23, 1956**

Brown, R. R.

*Journal of Geophysical Research*, v. 62, no. 1, pp. 147-154, March 1957

The cosmic ray event of February 23, 1956 represents the superposition of a flare increase and a broad Forbush-type intensity decrease. A model is proposed to account for the cosmic ray intensity observations during this event. (PA, v. 61, #4106)

**255. TIME VARIATIONS OF COSMIC-RAY INTENSITY**

Brown, R. R.

*Journal of Geophysical Research*, v. 61, no. 4, pp. 639-646, December 1956

The time variations of cosmic ray intensity associated with a large solar flare (February 23, 1956) and a period (January-March 1956) of strong solar activity are reported. A possible interpretation of these semi-regular time variations in terms of matter emanating from the Sun is considered. (PA, v. 61, #5095)

**256. COSMIC-RAY INTENSITY AT HIGH ALTITUDES ON FEBRUARY 23, 1956**

Van Allen, J. A. and McIlwain, C. E.

*Journal of Geophysical Research*, v. 61, no. 3, pp. 569-571, September 1956

**257. LARGE INCREASE OF COSMIC-RAY INTENSITY FOLLOWING SOLAR FLARE ON FEBRUARY 23, 1956**

Forbush, S. E.

*Journal of Geophysical Research*, v. 61, no. 1, pp. 155-156, March 1956; v. 62, no. 1, pp. 169-170, March 1957

**258. MEASUREMENT OF DENSITY DISTRIBUTION IN EXTENSIVE AIR SHOWERS**

Koch, J., Sandor, T., Somogyi, A., and Szilvek, J.

*Magyar Tudományos Akadémia Kozponti Fizikai Kutatóintézet Közleményei*, v. 1, no. 1-2, pp. 61-66, 1953 (Translated from *Referativnyi Zhurnal Fizika*, no. 2, 1957)

**259. STUDY OF EXTENSIVE AIR SHOWERS**

Janosay, L.  
*Magyar Tudomanyos Akademia Kozponti Fizikai  
Kutatointezet Kozlemenyei*, v. 1, no. 1-2, pp. 54-60,  
1953 (Translated from *Referativnyi Zhurnal Fizika*,  
no. 2, 1957)

**260. SOVIETS RELEASE SPUTNIK COSMIC  
RAY MEASUREMENTS**

*Missiles and Rockets*, v. 4, no. 21, p. 38,  
November 24, 1958

**261. OBSERVATION OF SOLAR COSMIC RAYS**

*National Academy of Sciences IGY Bulletin*,  
no. 25, pp. 1-5, July 1959

**262. SOLAR RADIO BURSTS AND LOW-ENERGY  
COSMIC RAYS**

Thompson, A. R. and Maxwell, A.  
*Nature*, v. 185, no. 4706, pp. 89-90,  
January 9, 1960

A discussion of observations which show that the radio bursts associated with the ejection of low-energy cosmic rays from the Sun take the form of an intense continuum, sometimes known as spectral Type IV.

**263. NORTH-SOUTH ANISOTROPY AND  
ANTICIPATORY INCREASE OF INTENSITY  
ASSOCIATED WITH THE COSMIC-RAY  
STORM OF FEBRUARY 11, 1958**

Sarabhai, V. and Palmeira, R.  
*Nature*, v. 184, no. 4694, pp. 1204-1207,  
October 17, 1959

**264. THE UPPER BOUNDARY OF THE  
VAN ALLEN RADIATION BELTS**

Snyder, C. W.  
*Nature*, Supplement, v. 184, no. 7, pp. 439-440,  
August 8, 1959

**265. SATELLITE OBSERVATIONS OF SOLAR  
COSMIC RAYS**

Rothwell, P. and McIlwain, C.  
*Nature*, v. 184, no. 4681, pp. 138-140, July 18, 1959

**266. RADIATION AROUND THE EARTH TO A  
RADIAL DISTANCE OF 107,400 KM**

Van Allen, J. A. and Frank, L. A.  
*Nature*, v. 183, pp. 430-434, February 14, 1959

Radiation detectors and the radio-telemetry system for *Pioneer III* observations of the Earth's radiation belt are described. Information is given on the vehicle and its trajectory, and logs of flight and telemetry. Observation data and analysis of the data are presented under the following topics: intensity-structure of the region of trapped radiation; effective radial extent of the geomagnetic field; interplanetary value of cosmic ray intensity; fluctuations in counting rate beyond 10 Earth radii, and biological exposure levels. (*NSA*, v. 13, #9162)

**267. STORM-TIME INCREASE OF COSMIC-RAY  
INTENSITY**

Yoshida, S. and Wada, M.  
*Nature*, v. 183, pp. 381-383, February 7, 1959

An analysis is given of two typical sudden increases in cosmic ray intensity observed on September 13, 1957, and February 11, 1958. These are shown to have been world-wide in incidence, and to have coincided with severe magnetic storms; large solar flares were observed approximately two days before. (*PA*, v. 62, #8273)

**268. SPACE RESEARCH**

Boyd, R. L. F.  
*Nature*, v. 183, pp. 361-364, February 7, 1959

Report of a conference arranged by the Royal Society on November 12-13, 1958, at which achieved and projected experiments in rockets and artificial satellites were discussed. Summaries are given of the main points treated, viz., oblateness of the Earth; atmospheric composition and temperature, including ionospheric measurements; cosmic rays; Van Allen Radiation Belt and its association with aurorae; micrometeors, extraterrestrial astronomy, including the use of optical, radio, X-ray, and  $\gamma$ -ray wavelengths; studies of the Moon, Mars and Venus. Practical problems include the recovery of information and position determination. The interpretation of the results obtained include the possibility that the Earth is situated in an extended solar corona. (*PA*, v. 62, #6439)

**269. AIR SHOWERS OF SIZE GREATER THAN  $10^5$  PARTICLES. 4. THE DISTRIBUTION OF NUCLEAR ACTIVE PARTICLES AND OF  $\mu$ -MESONS**

Lehane, J. A., Millar, D. D., and Rathgeber, M. H.  
*Nature*, v. 182, no. 4651, pp. 1699–1704,  
December 20, 1958

**270. A SURVEY OF THE COSMIC-RAY NUCLEONIC COMPONENT ALONG  $145^\circ$  EAST LONGITUDE, USING AN AIRBORNE MONITOR**

Storey, J. R., Fenton, A. G., and McCracken, K. G.  
*Nature*, v. 181, pp. 1155–1156, April 19, 1958

The survey, carried out to provide information to assist in finding a system of coordinates for the description of the Earth's effective magnetic field for cosmic rays was made between  $38^\circ\text{S}$  and  $34^\circ\text{N}$ , and from  $38^\circ\text{S}$  to  $52^\circ\text{S}$ . The minimum point of the latitude-intensity curve lies at  $7.1 \pm 0.5^\circ\text{N}$  geographic latitude. This result gives support to the suggestion that the cosmic ray equator follows the magnetic dip equator rather than the rotated dipole equator. It is suggested that at intermediate latitudes conventional geomagnetic coordinates are to be preferred to rotated dipole coordinates, since they preserve symmetry between the observed positions of the "knee" of latitude intensity curves in the two hemispheres. (*PA*, v. 62, #7158)

**271. A LARGE COSMIC-RAY DECREASE ACCOMPANYING THE SOLAR MAXIMUM OF 1957**

Winckler, J. R. and Peterson, L.  
*Nature*, v. 181, pp. 1317–1319, May 10, 1958

Several observations of the general cosmic ray level at balloon altitudes have been made which show a very large decrease in intensity during the spring and summer of 1957 compared with 1955 and 1956. The observations are of two types, the first made with a small Geiger counter vertical telescope of stopping power  $0.2 \text{ g/cm}^2$ , and the second with a combination of Geiger counter and ionization chamber. The 1957 measurements were made at latitudes of  $51.2^\circ$ ,  $55.3^\circ$ , and  $58.6^\circ$  in June for comparison with the earlier measurements at latitudes from  $51.2^\circ$  to  $64.2^\circ$ . The vertical particle flux has decreased at all atmospheric depths less than  $300 \text{ g/cm}^2$ , and the change

increases with decreasing depth until at high altitudes and high latitudes it almost reaches a factor of two. (*NSA*, v. 12, #9248)

**272. COSMIC RAYS AND THE SUNSPOT CYCLE. PRIMARY  $\alpha$ -PARTICLE INTENSITY AT SUNSPOT MAXIMUM**

Freier, P. S., Ney, E. P., and Fowler, P. H.  
*Nature*, v. 181, pp. 1319–1321, May 10, 1958

Emulsion stacks were exposed during the balloon flights (see *PA*, v. 61, #4109). The total vertical flux in June 1957 was  $157 \pm 17$  peters ( $\text{particles m}^{-2} \text{ sec}^{-1} \text{ sterad}^{-1}$ ), only 55 percent of the 1954 and 1956 values. No sharp low-energy cutoff was found, and both the lower and higher energy flux were reduced. Proposed modulation mechanisms are discussed. (*PA*, v. 61, #4110)

**273. EFFECTIVE MAGNETIC MERIDIAN FOR COSMIC RAYS**

Storey, J. R., Fenton, A. G., and McCracken, K. G.  
*Nature*, v. 181, p. 34, January 4, 1958

A determination of the "cosmic ray meridian" (defined as the line on the Earth's surface along which the rate of change of cosmic ray intensity is greatest) through Melbourne was made with an airborne neutron intensity monitor. The magnetic declination at Melbourne is  $10^\circ \text{ E}$  of N, the geomagnetic meridian  $9.5^\circ \text{ E}$  of N, while the meridian of the dipole, rotated  $45^\circ$  to the west, is  $14.5^\circ \text{ E}$  of N. The bearing of the cosmic ray meridian was found to be  $10^\circ \pm 4^\circ \text{ E}$  of N. This result suggests that the "rotated dipole" theory of the observed distribution of cosmic rays over the Earth's surface may be wrong. (*PA*, v. 61, #3214)

**274. THE COSMIC RAY FLARE OF 23 FEBRUARY 1956 AND ITS EFFECT ON THE NEW ZEALAND RADIOCARBON DATING EQUIPMENT**

Fergusson, G. J. and McCallum, G. J.  
*New Zealand Journal of Science and Technology*,  
Section B, v. 38, no. 6, pp. 577–587, May 1957

The flare was detected by the New Zealand radio-carbon dating equipment as an increase in the background counting rate. A comparison of the increase of

meson and neutron intensity showed that  $58.5 \pm 2.6$  percent of the normal background rate is caused by the nucleonic component of the cosmic radiation. Consideration has been given to the mechanisms by which the proportional counter detects the nucleonic component. As the sensitivity of the counter to this component cannot be decreased easily, a neutron monitor has been installed to monitor the intensity of the nucleonic component. (PA, v. 62, #2473)

**275. A COSMIC RAY JET IN THE  $10^{15}$   
ELECTRON VOLT ENERGY RANGE**

Fowler, P., Freier, P. S., Ney, E. P., Perkins, P. H.,  
and Lattes, C. M. G.

*Notas de Fisica*, v. IV, no. 9, 7 pp., May 19, 1958

A 22.4-liter stack of emulsions was exposed in Minnesota in September 1956 in a balloon flight at 116,000 feet. The emulsion stack weighed 200 lbs and had dimensions of  $16 \times 12 \times 7$  in. The largest jet found by naked-eye scanning traversed the entire Minnesota half of the stack with a total length of 26 cm. The electromagnetic cascade appeared to be initiated by several gamma rays probably from the decay of two neutral mesons. The energy of the primary alpha particle was estimated to be  $\geq 10^{15}$  electron volts. (NSA, v. 13, #2419)

**276. ON THE RELATIVE ABUNDANCE OF  
CARBON, NITROGEN, AND OXYGEN IN  
THE COSMIC RAYS**

Orsini, C. Q.

*Nuovo cimento*, II, v. 16, no. 6, pp. 1040-1045,  
June 16, 1960

Plates (33 G-5 emulsion) were exposed at an atmosphere depth of approximately 6 g/m<sup>2</sup>. Gap length measurements of 220 medium nuclei have these ratios C:N:O::1.5:0.97:1.0. By using different parameters in the diffusion equation agreement with the values of Suess and Urey's cosmic abundances could not be obtained. The results indicate that the chemical composition of the sources of cosmic rays is different from the mean composition of the Universe.

**277. A FAST HYPERFRAGMENT PRODUCED BY  
A HEAVY PRIMARY COSMIC RAY**

Camerini, U., Fry, W. F., Groves, T., and Huzita, H.

*Nuovo cimento*, II, v. 15, no. 3, pp. 498-499,

February 1, 1960

In an attempt to achieve higher nuclear excitation energies in interactions and correspondingly more energetic hyperfragments, a search has been made for hyperfragments produced by heavy primaries from the cosmic rays ( $Z > 3$ ). A nuclear emulsion stack was flown over Texas for eight hours above 104,000 ft and was scanned for entering heavy primaries. The results of this experiment are given.

**278. ON THE RELATIVE ABUNDANCES OF  
COSMIC RAY NUCLEI OF CHARGE  $Z \geq 3$**

Garelli, C. M., Quassiat, B., and Vigone, M.

*Nuovo cimento*, II, v. 15, no. 1, January 1, 1960

The charge spectrum of heavy primary ( $Z \geq 3$ ) of cosmic radiation has been measured in nuclear emulsion exposed in a high altitude balloon flight at a residual atmospheric thickness of about 6 g/cm<sup>2</sup>. The fluxes of light, medium and heavy nuclei at the top of the atmosphere, and also the relative abundances of charges between  $Z = 3$  and  $Z = 14$ , are given.

**279. INVESTIGATION OF THE EXISTENCE OF  
PARTICLES OF MASS ABOUT  $550 m_e$  IN  
COSMIC RAYS**

Conversi, M., De Munari, G. M., Egidi, A.,

Fiorini, E., Ratti, S., Rubbia C., Succi, C., and

Torelli, G.

*Nuovo cimento*, II, (in Italian) v. 12, no. 2,  
pp. 148-155, April 16, 1959

The results are reported of a cosmic ray experiment carried out at an altitude of 2550 m above sea level to search for the 550 mass particles reported by Alihanian, et al. No event has been found out of 25 expected on the basis of the rate given by these authors. This negative result is compared with the results of other workers. The possibility for pions and protons to appear as 550 mass particles when undergoing unidentified nuclear interactions is discussed. (PA, v. 62, #8268)

**280. INTERACTIONS OF THE HEAVY NUCLEI  
OF COSMIC RAYS IN CARBON**

Hirashima, Y.

*Nuovo cimento*, II, v. 12, no. 1, pp. 1-15,

April 1, 1959

The fragmentation probabilities of the heavy nuclei of cosmic rays have been investigated in carbon. Emulsion chambers consisting of carbon plates between nuclear emulsions exposed in Japan ( $\lambda = 25^\circ\text{N}$ ) were used. The charges of the heavy nuclei with  $Z \geq 3$  were determined by measuring the  $\delta$ -ray densities. The fragmentation probabilities into the light nuclei are  $P_{HL} = 0.35 \pm 0.08$  and  $P_{ML} = 0.35 \pm 0.08$ . The abundances at the balloon flight altitudes observed by several groups were extrapolated to the top of the atmosphere by using the fragmentation probabilities in carbon obtained in the present work. The ratio of the light nuclei to the medium nuclei at the top of the atmosphere is probably in the range from  $\sim 0.1$  to  $\sim 0.2$ . (PA, v. 62, #7143)

**281. RAPID DECREASE OF COSMIC RAY  
INTENSITY**

Steljes, J. F. and Carmichael, H.

*Nuovo cimento*, II, v. 10, no. 2, pp. 393-394,

October 16, 1958

A decrease of up to 6 percent in the neutron component on February 11, 1958 is related to a smaller decrease in the meson flux. It appeared to begin about 5 min before a magnetic storm, and was complete about 30 min sooner than the main meson decrease. (PA, v. 62, #3619)

**282. THE INTENSITY AND ANGULAR  
DISTRIBUTION OF MU-MESONS 1100  
FEET UNDERGROUND**

Randall, C. A. and Hazen, W. E.

*Nuovo cimento*, II, v. 10, no. 8, pp. 878-881,

June 16, 1958

The results of the determination of the intensity and angular distribution of the  $\mu$  mesons at a depth of  $8.5 \times 10^4$  g/cm<sup>2</sup> underground are  $I = I_0 \cos^n \theta$  with  $I_0 = (2.10 \pm 0.5) \times 10^{-6}$  s<sup>-1</sup> cm<sup>-2</sup> sr<sup>-1</sup> and  $n = 2.3 \pm 0.3$ . The significance of the results in determining the parentage of the  $\mu$ -mesons is discussed. (NSA, v. 12, #15,634)

**283. A SEARCH FOR PARTICLES OF 550  $m_e$**

Conversi, M., Fiorini, E., Ratti, S., Rubbia, C.,  
Succi, C., and Torelli G.

*Nuovo cimento* II, v. 9, no. 4, pp. 740-744,

August 16, 1958

An arrangement of two cloud chambers and a proportional liquid scintillation counter was used at an altitude of 2550 m to measure the ionization and residual range of cosmic ray particles entering the apparatus. No evidence has yet been obtained for particles of mass in the region of 500  $M_e$ , though the authors estimate that six might have been expected on the basis of results reported by Alikhanyan, et al. (PA, v. 62, #3612)

**284. HEMISPHERICAL DISTRIBUTION OF  
COSMIC RAYS AT 25° GEOMAGNETIC  
LATITUDE**

Gill, P. S. and Mitra, A. N.

*Nuovo cimento*, II, v. 9, no. 2, pp. 400-411,

August 1, 1958

A complete investigation has been made of the angular distribution (over various zeniths and azimuths) of the hard component of cosmic rays at the Gulmarg High Altitude Research Observatory (geomagnetic latitude  $24.7^\circ\text{N}$ ). The azimuth distribution is found to agree closely with an energy law  $E^{-1.80} dE$  for all the zenith angles. The zenithal distribution is found to be a cosine power law in which the index  $n$  varies regularly with azimuth. A sinusoidal dependence of  $n$  on azimuth has also been obtained by the method of least squares. (PA, v. 61, #8097)

**285. LATITUDE VARIATION OF 27-DAY COSMIC  
RAY INTENSITY DECREASES**

Brown, R. R.

*Nuovo cimento*, II, v. 9, no. 2, pp. 197-207,

July 16, 1958

The latitude variation of cosmic ray intensity decreases due to the modulation effects of a geocentric nebula of disordered magnetic fields is calculated. Experimental data provided by neutron monitor observations during a period of intense solar activity, when compared with the results of these calculations, show that equatorial variations exceed those given by the modulation mechanism by a factor of two or more. (PA, v. 61, #8096)



**286. THE CHARGE SPECTRUM OF THE COSMIC RADIATION AT 41°N**

Koshiba, M., Schultz, G., and Schein, M.

*Nuovo cimento, II*, v. 9, no. 1, pp. 1-16, July 1, 1958

From a large stack of G-5 emulsions flown at Texas, 41°N geomagnetic latitude, the charge spectrum of the cosmic radiation at 104,000 ft was obtained. Special emphasis is given to the observation of the detailed shape of the spectrum in the region  $Z \geq 9$ . The gap-counting is extensively used even at these high  $Z$  values after very careful calibration with break-up events and  $\delta$ -ray countings. The charge spectrum thus obtained was extrapolated to the top of the atmosphere by making use of the fragmentation probabilities in air which were obtained from the analysis of a total of 209 interactions in the same stack. This extrapolation gives for the ratio of the light nuclei,  $L$ , ( $Z = 3, 4$  and  $5$ ) and heavy nuclei,  $H$ , ( $Z \geq 9$ ), to the medium ones,  $M$ , ( $Z = 6, 7$  and  $8$ ) the values  $0.32 \pm 0.07$  and  $0.48 \pm 0.01$ , respectively, at the top of the atmosphere. The fragmentation probabilities in hydrogen, the main constituent of interstellar matter, were also obtained from the careful study of the interactions in the stack and allowed to make a further extrapolation of the charge spectrum from the top of the atmosphere to the one at the source region of the cosmic radiation. The ratio of the heavy nuclei to the medium ones was found to be  $0.66 \pm 1.6$  at the source. This charge spectrum at the source region is compared with the average chemical abundances of the elements in the universe as well as with those in certain types of stars. The results seem to indicate a close similarity of the chemical abundance curve of the cosmic radiation with that of certain types of young stars. (PA, v. 62, #375)

**287. THE ZENITHAL DISTRIBUTION OF THE COSMIC RAY NEUTRONS IN THE HIGH ENERGY RANGE**

Fidecaro, M. C., Fidecaro, G., Marini, G., and Mezzetti, L.

*Nuovo cimento, II*, v. 9, no. 1, pp. 37-58, July 1, 1958

The zenith angle distribution of cosmic-ray neutrons in the energy range  $> \sim 10$  BeV was measured at an altitude of 3500 m above sea level ( $679 \text{ g/cm}^2$ ) by means of a penetrating shower detector associated with a large area Geiger-counter hodoscope. The penetrating showers were generated in thin layers of paraffin and graphite. The

instrumental bias and the systematic errors in the determination of the angles are discussed, and corrections applied whenever possible. The corrected distribution is well approximated with a law of the type  $\exp[-m/\cos \theta]$  with  $m = 7.1 \pm 1.3$ , in agreement with the results of Walker. The discussion shows that this value has to be considered as a lower limit for the true  $m$  and is therefore difficult to reconcile with the assumption that the zenithal distribution is due solely to the absorption of the particles of the nuclear cascade in the atmosphere, with a mean free path  $\lambda_a = 130 \text{ g/cm}^2$  as determined by several authors. From the hodoscope information the angular distribution of ionizing secondaries around the direction of the primary neutron is also calculated. The distributions obtained for penetrating showers produced in carbon and in hydrogen are very similar. The analysis in terms of an isotropic distribution in the center of mass system of the incident neutron and a target nucleon yields an average energy of the observed events  $E = 24$  BeV. The experimental results on the zenithal distribution are compared with the distributions calculated with the theory of the nuclear cascade in the atmosphere, as developed by Budini and Molière. It is shown that the finite lifetime of some of the particles belonging to the  $N$  component cannot account for the "anomalous" zenithal effect indicated by the measurements. It is suggested that the discrepancy may be removed with the choice of a value of the anelasticity parameter much greater than that assumed by Budini and Molière. (PA, v. 62, #385)

**288. ASSOCIATED PRODUCTION OF A  $K^+$ -MESON AND A HYPERFRAGMENT**

Tsai-Chu, Chemel, B., and Desprez-Rebaud, S.

*Nuovo cimento, II*, v. 9, no. 1, pp. 192-194, July 1, 1958

This event was found in cosmic ray exposed emulsion. The  $K$ -meson was identified by the ionization-scattering method. The hyperfragment was probably  $\text{Be}_\alpha^8$ . Kinematical arguments are used to suggest that the neutral primary of the star was a photon. (PA, v. 61, #8855)

**289. IDENTIFICATION OF FAST HEAVY NUCLEI OF THE COSMIC RADIATION USING NUCLEAR EMULSION TECHNIQUES**  
O'Brien, B. J. and Noon, J. H.

*Nuovo cimento, II, Series 10, v. 8, pp. 807-825,  
June 16, 1958*

Measurements were made of six parameters of tracks of nuclei with  $4 \leq Z \leq 9$  in a stack of G-5 stripped emulsion flown at  $41^\circ\text{N}$  geomagnetic latitude. The  $\delta$ -ray, blob, and isolated-grain densities, the Fowler-Perkins coefficient, integral gap length, and probability of development have been found for each track. Estimates have been made of the effect of various sources of error in these measurements, including a study of the change in each measured parameter with a 20 percent in minimum grain density of the emulsion. From the comparison and analysis of these measurements, recommendations are given on the use of the above techniques in the identification of fast heavy nuclei in nuclear emulsion. (NSA, v. 12, #15,633)

**290. INTERNATIONAL CONVENTION ON  
COSMIC RAYS**

*Nuovo cimento, II, v. 8, Supplement no. 2,  
pp. 125-804, 1958*

The text of 90 papers dealing with various aspects of cosmic radiation is given.

**291. NEUTRAL V-PARTICLE FROM COPPER  
AND CARBON**

Cooper, W. A., Filthuth, H., Montanet, L.,  
Newth, J. A., Petrucci, G., Salmeron, R. A., and  
Zichichi, A.

*Nuovo cimento, II, Series 10, v. 8, pp. 471-479,  
May 1, 1958*

The results of a cosmic ray experiment on the production of neutral V particles in copper and carbon are given. The conclusions are based on the analysis of 51  $V^0$  events from copper and 28 from carbon. The ratio of number of  $\Lambda^0$  particles to number of short-lived  $\theta^0$  particles at production is found to be  $\sim 1:1$  in copper and  $\sim 1:2$  in carbon before allowance is made for the decay modes involving only neutral particles. The momentum aspects found for the  $V^0$  particles agree with earlier results. A possible asymmetry in the decay of  $\Lambda^0$  particles is discussed, and estimates of the mean lifetimes of  $\Lambda^0$  and  $\theta^0$  particles are given. (NSA, v. 12, #13,213)

**292. COSMIC RAY SOFT COMPONENT  
MEASUREMENTS DURING A FLIGHT  
FROM SCANDINAVIA ACROSS THE  
NORTH POLE AND AROUND ASIA AND  
EUROPE**

Sandström, A. E.

*Nuovo cimento, II, Series 10, v. 8, Supplement  
no. 2, pp. 263-276, 1958*

During the geophysical year cosmic ray measurements, including those with neutron monitors, were to be made at a number of stations in the northern polar region. Plans called for the collection of data on the soft component variations across this region along two meridians as opposite to each other as possible. With the aid of the Scandinavian Airlines System this project was undertaken, the neutron monitor being returned along the usual commercial flight routes over the southern parts of Asia and Europe. The survey includes several regions inaccessible by shipborne instruments. Some of the results of data taken so far are graphically shown. (NSA, v. 13, #7984)

**293. SHIPBOARD NEUTRON MONITOR  
DETERMINATION OF COSMIC-RAY  
EQUATOR**

Pomerantz, M. A., Sandström, A. E., and Rose, D. C.

*Nuovo cimento, II, Series 10, v. 8, Supplement  
no. 2, pp. 257-262, 1958*

It is known that the dipole approximation to the Earth's magnetic field derived from surface measurements does not provide adequate geometric coordinates for describing the observed spatial distribution of cosmic ray intensities. To facilitate a detailed analysis of this problem a global map of the contours of equal ray intensity is being made using neutron monitors on shipboard. Since the program is still in progress, no attempt is made to present all the results obtained thus far or to discuss the implications in detail. (NSA, v. 13, #7983)

**294. RAPID DECREASE OF COSMIC-RAY  
INTENSITY**

Palmeira, R. A. R. and Williams, R. W.

*Nuovo cimento, II, v. 8, no. 2, pp. 352-355,  
April 16, 1958*

A sudden decrease in cosmic ray  $\mu$ -meson counting-rate, associated with the magnetic storm auroral display of 10 February 1958, was recorded on a high counting-

rate, high time-resolution meson monitor, composed of large disks of plastic scintillator. In this event, which resembled a Forbush decrease except that the time-scales were shorter, the cosmic ray intensity dropped by 2.1 percent in about 1 hr, remained at that level for a few hours, and then gradually rose to its original value, in a total time of about 14 hr. Since the median energy of the primaries of the mesons recorded is about 10 Bev, a lower limit of  $5 \times 10^{-5}$  gauss for the magnetic field of the solar gas cloud, which excluded a fraction of cosmic rays from the Earth, may be deduced from these results. (PA, v. 61, #4111)

**295. ON THE CHARGE AND ENERGY SPECTRUM OF HEAVY PRIMARIES IN COSMIC RADIATION**

Cester, R., Debenedetti, A., Garelli, C. M., Quassiat, B., Tallone, L., and Vigone, M.  
*Nuovo cimento, II*, Series 10, v. 7, pp. 371–399, February 1, 1958

Several hundred tracks of heavy primaries in the cosmic radiation have been studied. Charge measurements have been carried out on all tracks with a photometric method, and independent checks with gap counting have been performed on boron and carbon tracks. All tracks have been followed through and a total of 331 nuclear collisions observed. From the analysis of these interactions, the interaction mean free paths, and fragmentation probabilities in emulsion and in air have been determined. The results are in good agreement with those of other workers and have been used to extrapolate the charge distribution at the top of the atmosphere; the ratios of light nuclei and of heavy nuclei to medium nuclei, at the top of the atmosphere, are  $0.30 \pm 0.09$  and  $0.51 \pm 0.11$  respectively. Results of energy determination on 275 tracks give a value  $1.54^{+0.16}_{-0.13}$  for the exponent of the integral energy spectrum. Some difficulties in the application of Peters' relation between the energy of primary and the angles of emission of the fragmentation products are discussed. (NSA, v. 12, #7894)

**296. FLUX OF SLOW  $\mu$ -MESONS AND PROTONS NEAR THE GEOMAGNETIC EQUATOR**

Subramanian, A., Naranan, S., Ramanamurthy, P. V., Sahiar, A. B., and Lal, S.  
*Nuovo cimento, II*, v. 7, no. 1, pp. 110–113, January 1, 1958

The vertical fluxes of slow  $\mu$ -mesons and slow protons in air, have been evaluated at Ootacamund, 7,500 ft above sea level and  $\sim 2^\circ\text{N}$  geomagnetic latitude, using a multi-plate cloud-chamber triggered by a Geiger counter telescope. These fluxes are given as  $(3.7\text{--}4.4) \times 10^{-6}$ , and  $(0.9\text{--}1.1) \times 10^{-6}$  particles per g of air per sec per steradian for  $\mu$ -mesons and protons respectively. The latitude effect for slow mesons between  $2^\circ\text{N}$  and  $50^\circ\text{N}$  is calculated to lie between 2.7 and 3.4, while the latitude effect for slow protons between  $2^\circ\text{N}$  and  $50^\circ\text{N}$  is calculated to be between 2.7 and 5.5. These values are compared with values for the latitude effect obtained by other workers. (PA, v. 61, # 2376)

**297. THE AVERAGE MULTIPLICITY AND INELASTICITY IN  $\pi$ -MESON PRODUCTION IN THE ATMOSPHERE**

Ishikawa, G. and Maeda, K.  
*Nuovo cimento, II*, v. 7, no. 1, pp. 53–66, January 1, 1958

The energy spectra of primary and secondary cosmic radiation are analyzed to find the multiplicity–energy relation in the  $\pi$ -meson production in the atmosphere at the energy region from several Bev to some thousands Bev with the help of simplified considerations on the meson production by nucleus–nucleus collisions. The results being subjected to the assumed values of inelasticity suggest that the multiplicity–energy relation agrees with the formula of the type given by Fermi and Landau under the condition of a practically constant small inelasticity. (PA, v. 61, #1118)

**298. ON THE NUCLEON-NUCLEON INTERACTION WITH ENERGY HIGHER THAN  $10^{14}$  ev**

Ciok, P., Danysz, M., Gierula, J., Jurak, A., Miesowicz, M., Pernegr, J., Vrána, J., and Wolter, W.  
*Nuovo cimento, II*, v. 6, no. 6, pp. 1409–1415, December 1957

A jet  $0 + 14\alpha$  of energy  $3.3 \times 10^{14}$  ev is described. It was found that the distribution of charged particles is asymmetric in the center-of-mass system but becomes symmetric when the neutral particles have been taken into consideration. The information about the neutral particles was obtained from the development of the electronic component of the shower. The angular distribution in the center-of-mass system is strongly anisotropic and

near to Heisenberg's distribution. The energy of the secondary particles in the center-of-mass system is of the order of a few Bev and transversal momenta given for two secondaries are of the order of several hundred Mev/c. The inelasticity coefficient is  $\sim 0.1$ . (PA, v. 61, #1117)

- 299. THE FORMATION OF  $^{22}\text{Na}$  FROM ATMOSPHERE ARGON BY COSMIC RAYS**  
Marquez, L., Costa, N. L., and Almeida, I. G.  
*Nuovo cimento, II*, v. 6, no. 6, pp. 1292-1295,  
December 1957

It was found that  $\text{Na}^{22}$  is formed as a spallation product of atmospheric argon by cosmic rays. It was isolated from the fresh rainwater of Rio de Janeiro, and its average activity is 0.017 d.p.m./litre. (PA, v. 61, #1116)

- 300. THE 24 HOUR INTENSITY VARIATIONS OF THE PRIMARY COSMIC RAYS**  
Conforto, A. M. and Simpson, J. A.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 1052-1063,  
November 1957

The data from nucleonic component detectors (neutron intensity monitors) are analyzed for the amplitude and phase of maximum intensity of the 24 hr variation at the geomagnetic equator and at  $48^\circ\text{N}$ . The same analysis is performed on selected charged particle detectors. The analysis covers 1953-1955, which includes the time of solar cycle (sunspot) minimum in 1954. During 1954 it is known that the 24 hr variation possesses an anomalous behavior. It is shown that during 1954 there is an interval of nine months or more when the solar daily variation appears to undergo a progressive phase shift whose time of maximum lies in the range of 0800-1000 hr on a sidereal time scale. This anisotropy certainly exists in the radiation falling upon the atmosphere, and it is likely, although not proven, that the anisotropy prevails even outside the terrestrial field. The question of whether this sidereal effect is spurious or real is discussed in relationship to the recent results on the modulation of cosmic ray intensity within the solar system. (NSA, v. 12, #4265)

- 301. A CORRECTION TO PREVIOUSLY QUOTED COSMIC RAY FLUX VALUES**  
Waddington, C. J.  
*Nuovo cimento, II*, v. 10, no. 6, pp. 748-750,  
September 1958

A systematic error of somewhat more than 10 percent in nuclear emulsion measurements of cosmic ray flux is pointed out. This error arises from the failure to allow for the particles that enter the emulsions while they are rising to ceiling altitude during the exposure, and cause the fluxes to be overestimated. Corrections for this are proposed. (NSA, v. 12, #1461)

- 302. ANOMALOUS HEAVY PRIMARY CASCADES RECORDED ON VIKING 10 ROCKET FLIGHT**  
Yagoda, H.  
*Nuovo cimento, II*, v. 6, no. 3, pp. 559-570,  
September 1957

Emulsions flown to 136 miles on Viking-10 surrounded by only  $2 \text{ g/cm}^2$  of superimposed metallic absorber recorded two examples of heavy primaries which on collision with emulsion nuclei are not destroyed catastrophically. The heavily-charged relativistic fragments emerging from the primary act produce secondary collisions after traversing distances that are small compared with the collision mean free path of the identified nuclei. The first event initiated by a particle of charge  $14 \pm 1$  encompasses a total of 5 collisions which could originate by successive chance deviations from the geometric mean free path with a probability of  $1.3 \times 10^{-6}$ . The second cascade initiated by a carbon nucleus passes through two stages, and has its charge reduced to  $Z = 3$  before the latter escapes from the detector. Considerations of the relative frequency of different modes of fragmentation and geometric escape further reduce the probability of these events originating by chance and being detected. (PA, v. 61, #644)

- 303. EFFECTS OF NON-PRIMARY COSMIC RADIATION ON THE NUMBER-ENERGY RELATION AND GEOMAGNETIC CORRELATIONS NEAR THE TOP OF THE ATMOSPHERE**  
Anderson, K. A.  
*Nuovo cimento, II*, Series 10, v. 5, Supplement,  
no. 3, pp. 389-416, 1957

Experimental results for flights at the geomagnetic latitudes  $10^\circ$  and  $55^\circ \text{N}$  in 1953 are presented. The data are presented in total flux as a function of atmospheric depth, pulse-height distributions during ascent, and fast

albedo and slow proton intensities at 0 and 60° zenith angles. The character of the splash albedo is illustrated by plots of its dependence on geomagnetic latitude, zenith and azimuthal angle, and on atmospheric depth. (NSA, v. 12, #1459)

**304. THE SOLAR DIURNAL VARIATION OF THE INTENSITY OF THE NUCLEONIC COMPONENT OF THE COSMIC RADIATION**

Marsden, P. L. and Begum, Q. N.

*Philosophical Magazine, The*, v. 4, no. 47, pp. 1247-1254, November 1959

The diurnal variation of the intensity of the nucleonic component of the cosmic radiation detected at the laboratory of the Physics Department of the University of Leeds through the period 1954-1958 has been analyzed.

**305. THE APPARENT SIDEREAL DAILY VARIATION OF COSMIC RAY INTENSITY DURING THE RECENT SUNSPOT MINIMUM**

Baliga, S. P. and Thambyahpillai, T.

*Philosophical Magazine, The*, v. 4, no. 44, pp. 973-984, August 1959

**306. ANALYSIS OF NUCLEAR INTERACTIONS OF ENERGIES BETWEEN 1000 AND 100,000 Bev**

Edwards, B., Losty, J., Perkins, D. H., Pinkau, K., and Reynolds, J.

*Philosophical Magazine, The, Eighth Series*, v. 3, pp. 237-266, March 1958

Twenty nuclear interactions produced by protons and ten produced by  $\alpha$  particles of energies above 1000 Bev have been analyzed. The proportion of pions among the secondaries is found to be 80 percent for the core and less than 70 percent for the wide angle tracks. The average transverse momentum resulting from the measurements is  $p_T = 0.5$  Bev/c for pions and  $p_T = 1$  to 2 Bev/c for heavy particles. It appears to be independent of angle of emission and primary energy. The multiplicity of the interaction,  $n_s$  shows no variation with primary energy; it varies, however, with the anisotropy of the angular distribution, and shows wide fluctuations at a fixed primary energy. The inelasticity,  $K$ , of the collisions is close

to unity for secondary interactions of mean energy  $\sim 100$  Bev and about 0.2 for jets produced by protons of energy  $\sim 10,000$  Bev. At a fixed energy,  $K$  does not appear to be strongly dependent on  $n_s$ . None of the current theories appears capable of giving a satisfactory explanation of the experimental results, and an alternative model is proposed. (NSA, v. 12, #7898) See also *Philosophical Magazine, The*, v. 4, p. 90, 1959.

**307. FURTHER INTERACTIONS OF THE HEAVY NUCLEI OF THE COSMIC RADIATION**

Rajopadhye, V. Y. and Waddington, C. J.

*Philosophical Magazine, The, Eighth Series*, v. 3, pp. 19-32, January 1958

Earlier results obtained at Bristol from a study of nuclear interactions produced by heavy nuclei of the primary cosmic radiation passing through nuclear emulsions have been amplified and confirmed. Revised values are given for the fragmentation probabilities and mean free paths which are of greater statistical weight and in good agreement with those reported previously. Values are derived from the fragmentation probabilities in air and in hydrogen which probably represent upper limits to the true values. The implications of the results are discussed. (NSA, v. 12, #7896)

**308. TIME VARIATIONS OF THE COSMIC RAY INTENSITY IN JAMAICA**

Barton, J. C. and Stockhausen, J. H.

*Philosophical Magazine, The, Eighth Series*, v. 3, pp. 55-62, January 1958

A three-fold counter telescope has been used to study the radiation penetrating 10 cm of lead at a latitude of 18°N. A barometric coefficient of  $-0.14 \pm 0.02$  percent per millibar was deduced from the semi-diurnal variation. The average counting rate decreased on days of high geomagnetic activity and at the same time there was a large increase in the diurnal variation. (NSA, v. 12, #7897)

**309. NUCLEAR INTERACTIONS IN CARBON PRODUCED BY COSMIC RAYS WITH ENERGIES BETWEEN  $10^{10}$  AND  $10^{12}$**

Hansen, L. F. and Fretter, W. B.

*Physical Review, The*, v. 118, no. 3, pp. 812–824,  
May 1, 1960

An experiment is described in which high-energy nuclear interactions in the range of energies  $10^{10}$ – $10^{12}$  ev were analyzed by means of a cloud chamber in a magnetic field. Measurement of ionization and momentum made possible the identification of electrons and  $\pi$ -mesons to about 20 Bev/c. Protons, K-mesons, and hyperons could not be identified unambiguously among themselves, except in very limited regions of momentum. The primary particles were cosmic ray nucleons and a possible fraction of pions, the target nuclei were carbon and the velocities of the primaries were determined from balance of momentum in the center-of-mass system. A total of 41 events were analyzed, and the results compared to previous experimental work and the predictions of the theories of Heisenberg and Landau. The measurements made included the transverse moments of the secondaries and their average energy in the center-of-mass system, the energy and angular distributions of the pions and heavy particles (protons, K-mesons, hypersons) in the center-of-mass system, the inelasticity of the collision, the multiplicity of the showers, the percentage of strange particles, and the positive excess of the secondaries.

**310. HEAVY NUCLEI IN THE PRIMARY COSMIC RAYS OVER MINNESOTA**

Tamai, E.  
*Physical Review, The*, v. 117, no. 5, pp. 1345–1351,  
March 1, 1960

An analysis of the heavy primary cosmic rays ( $Z \geq 2$ ) has been made by using a stack of emulsions which was exposed at a high altitude on September 18, 1956 over Minnesota.

**311. LATITUDE EFFECT ON EXTENSIVE AIR SHOWERS OF COSMIC RAYS**

Ozaki, S.  
*Physical Review, The*, v. 117, no. 4, pp. 1125–1127,  
February 15, 1960

The variation of air shower counting rate with latitude has been measured between  $7^\circ$  and  $50^\circ$ N at sea level. The observed showers have  $10^6$  charged particles on the average.

**312. CHANGES IN THE DIFFERENTIAL RIGIDITY SPECTRUM OF PRIMARY COSMIC RAYS ASSOCIATED WITH LONG-TERM AND SHORT-TERM INTENSITY VARIATIONS**

Storey, J. R.  
*Physical Review, The*, v. 17, no. 2, pp. 573–577,  
January 15, 1960

During June and July, 1958, the cosmic ray nucleonic component was surveyed along the geographic longitude  $147.5^\circ$ E between geographic latitudes  $10^\circ$ S and  $44^\circ$ S ( $\lambda = 19^\circ$ S and  $53^\circ$ S) at atmospheric depth 475 g/cm<sup>2</sup> with a neutron monitor mounted in an aircraft.

**313. LOW ENERGY  $\pi$ -MESONS IN THE COSMIC RADIATION**

Fotion, M.  
*Physical Review, The*, v. 117, no. 1, pp. 243–246,  
January 1, 1960

The intensity of  $\pi$ -mesons in the atmosphere is investigated in the energy region  $E_{\text{kin}} < 50$  Mev at sea level and at mountain altitudes.

**314. PRIMARY COSMIC-RAY PROTON AND ALPHA-PARTICLE INTENSITIES AND THEIR VARIATION WITH TIME**

Meyer, P.  
*Physical Review, The*, v. 115, no. 6, pp. 1734–1741,  
September 15, 1959

A series of high-altitude balloon flights was carried out in 1957 and 1958 to study the flux of primary cosmic ray protons and  $\alpha$ -particles during variations in the total cosmic ray intensity. Independent  $\alpha$ -particle flux variations were observed and it is suggested that occasional solar production of  $\alpha$ -particles may be responsible.

**315. HEAVY PRIMARY COSMIC RAYS AT GEOMAGNETIC LATITUDE OF  $41^\circ$ N**

Young, O. B. and Chen, H. Y.  
*Physical Review, The*, v. 115, no. 6, pp. 1719–1721,  
September 15, 1959

This report includes the results from 9 balloon flights at geomagnetic latitude  $41^\circ$  N of altitude range from 70,000 to 100,000 feet. Only primaries of  $Z \geq 10$  are considered. 2410 tracks are involved, in Ilford G-5 and G-0 emulsion exposures. Given are the charge spectra, flux, mean free paths, and angular distributions.

**316. FLUX AND ENERGY SPECTRUM OF COSMIC-RAY  $\alpha$ -PARTICLES DURING SOLAR MAXIMUM**

Freier, P. S., Ney, E. P., and Waddington, C. J.  
*Physical Review, The*, v. 114, no. 1, pp. 365-373,  
April 1, 1959

The fluxes of primary cosmic-ray  $\alpha$ -particles over Minnesota and Texas were measured during the present period of maximum solar activity. A value of  $136 \pm 9$   $\alpha$ -particles/m<sup>2</sup> sec sterad was measured over Minnesota and of  $68 \pm 4$   $\alpha$ -particles/m<sup>2</sup> sec sterad over Texas. In both cases these values are significantly lower than those observed at solar minimum. The energy spectrum of these particles was determined between 200 Mev/nucleon and 3.0 Bev/nucleon. It is shown that the slope of the integral spectrum is less than that observed at solar minimum and that a significant number of low-energy particles is still present. A possible mechanism for these changes is discussed briefly. The determination of energies of particles from a measurement of their ionization is discussed in detail in an appendix. (PA, v. 62, #7136)

**317. GEOMAGNETIC MEASUREMENTS ON HEAVY PRIMARY COSMIC RADIATION NEAR THE EQUATOR**

Danielson, R. E.  
*Physical Review, The*, v. 113, no. 5, pp. 1311-1322,  
March 1, 1959

The azimuthal angular distribution of primary cosmic radiation with charges  $Z \geq 6$  has been measured near the geomagnetic equator (at Guam) in horizontal emulsions with known orientation relative to the Earth. The observed distribution is well described by using the centered-dipole approximation to the Earth's surface magnetic field (north pole at 79°N and 70°W) if the effect of the solid Earth is included by assuming that the main cone is the allowed cone. This verifies the prediction that the penumbra becomes forbidden near the geomagnetic equator. The main-cone equatorial cutoffs were applied to an assumed integral energy spectrum which is inversely proportional to the  $\alpha$  power of the total energy per nucleon. The exponent  $\alpha$  was found to be at least  $1.82 \pm 0.19$ . (PA, v. 62, #5863)

**318. POINT SOURCE OF COSMIC RAYS IN ORION**

Sekido, Y., Yoshida, S., and Kamiya, Y.

*Physical Review, The*, v. 113, no. 4, pp. 1108-1114,  
February 15, 1959

By using Geiger-Müller counter telescopes with alt-azimuth mountings, a point source of cosmic rays was found. The telescopes were kept nearly horizontal so as to observe only high-energy cosmic rays which could pass through the thick layer of the atmosphere. Upon scanning the celestial sphere, a small part of it was observed again and again during the period from April 1954 to December 1956, and thus the existence of a point source was established. The declination of the point source was about 0.5°N and the right ascension was about 5 hr 15 min. The average momentum of the primary particles effective for this observation would be about 280 Bev/c if they are protons. In this momentum range, the time average of the intensity was about 10 percent of the background cosmic rays, while there were some periodic variations during the period of observation. (PA, v. 62, #5857)

**319. LITHIUM, BERYLLIUM, AND BORON IN THE PRIMARY COSMIC RADIATION**

Freier, P. S., Ney, E. P., and Waddington, C. J.  
*Physical Review, The*, v. 113, no. 3, pp. 921-927,  
February 1, 1959

In order to resolve the controversy concerning the abundance of the light elements ( $3 \leq Z \leq 5$ ) in the primary cosmic radiation, a further experiment was performed. The charge spectrum of the cosmic radiation was determined on October 19, 1957 in a stack of nuclear emulsions exposed nearer the top of the atmosphere than before. The results of the experiment prove that these light elements make up an appreciable fraction of all those nuclei with  $Z \geq 3$  present in primary cosmic radiation. The flux values found after correction to the top of the atmosphere are, in particles/m<sup>2</sup> sec sterad:

Li, Be, B ( <i>L</i> nuclei),	$1.9 \pm 0.3$ ;
CNOF ( <i>M</i> nuclei),	$5.1 \pm 0.5$ ;
$Z \geq 10$ ( <i>H</i> nuclei),	$1.7 \pm 0.3$ .

These values appear to be lower than observed previously in agreement with the decrease in the  $\alpha$ -particle flux associated with the Sun's increased activity. (PA, v. 62, #7132)

**320. COSMIC-RAY INCREASES ASSOCIATED WITH SOLAR FLARES**

Towle, L. C. and Lockwood, J. A.

*Physical Review, The*, v. 113, no. 2, pp. 641-647,  
January 15, 1959

Data from a standard IGY neutron monitor located on Mount Washington, New Hampshire, have been examined for possible increases associated with solar flares. The 0400 and 0900 impact zones have been located for both the standard centered dipole and the westward rotated centered dipole approximations. No increases  $\geq 0.25$  percent have been found for the years 1956 and 1957. An additional maximum in the mean daily cycle at the time of impact zone passage has not been observed during this period. Possible explanations for this result are presented. (PA, v. 62, #4770)

**321. FURTHER EVIDENCE FOR A VARIATION  
IN THE RATE OF DENSE EXTENSIVE AIR  
SHOWERS WITH SOLAR TIME**

McCusker, C. B. A., Page, D. E., and Reid, R. A.  
*Physical Review, The, Second Series*, v. 113, no. 2,  
pp. 712-713, January 15, 1959

**322. VARIATIONS IN THE COSMIC-RAY  
RIGIDITY SPECTRUM**

McCracken, K. G.  
*Physical Review, The*, v. 113, no. 1, pp. 343-348,  
January 1, 1959

Variations in the counting rates of two different high-latitude neutron monitors, a high-latitude meson telescope, and a low-latitude neutron monitor were studied for the period August 1956, to January 1958. A long-term decrease in counting rate was observed at all stations, superposed on which there were numerous short-term variations of from 3 to 30 days duration. The long-term variation in neutron counting rate at high latitudes was four times greater than that at low latitudes, indicating that the change in the cosmic ray spectrum was most pronounced at low rigidities. The high-latitude short-term variations in neutron counting rate were about 2.5 times greater than those at low latitudes, the ratio varying from event to event. This is interpreted as evidence that the spectrum changes during short-term variations are less strongly dependent upon rigidity than in the case of the long-term variation, and that they are of a variable character. Comparison of the neutron data with simultaneous meson data supports this view. It is concluded that the long- and short-term variations in intensity are produced by different mechanisms. (PA, v. 62, #4769)

**323. COSMIC RAY LATITUDE SURVEY ALONG  
145° EAST LONGITUDE USING AN  
AIRBORNE NEUTRON MONITOR**

Storey, J. R.  
*Physical Review, The*, v. 113, no. 1, pp. 297-301,  
January 1, 1959

Describes a survey of the cosmic ray nucleonic component along the 145°E longitude between geographic latitudes 34°N (Tokyo) and 52°S. The instrument used was a Simpson-type neutron monitor installed in a Lincoln bomber and measurements were made at a pressure altitude of 20,000 ft (475 g/cm<sup>2</sup>). A check on the equipment performance was provided by covering the entire route twice. A Forbush-type intensity decrease was encountered during the southbound section between latitudes 5°S and 36°S. The cosmic ray equator was located at 7.1°N geographic (2.4°S geomagnetic) and the south cosmic ray knee, defined as the latitude south of which there is no further increase of intensity with latitude, occurred at 43.5°S geographic (52.3°S geomagnetic). The survey north of Melbourne (38°S geographic) was completed between July 18 and August 6, 1957. Flights south from Melbourne were made on August 19 and 21, 1957. (PA, v. 62, #4767)

**324. LATITUDE DEPENDENCE OF A FORBUSH-  
TYPE COSMIC-RAY INTENSITY DECREASE  
OBSERVED AT AIRCRAFT ALTITUDE**

Storey, J. R.  
*Physical Review, The*, v. 113, no. 1, pp. 302-304,  
January 1, 1959

During an aerial survey of the cosmic ray nucleonic component along the longitude 145°E, two southbound flights between geographic latitudes 5°S and 36°S were made under depressed cosmic ray intensity following the Forbush-type decrease commencing August 4, 1957. Comparison of the intensity vs. latitude plot with that obtained during the northbound flights over the same route when quiet cosmic ray conditions prevailed enabled the latitude dependence of the decrease to be determined. It is found that for the event investigated, the percentage decrease was independent of latitude over the range 5°S to 36°S geographic (14°S to 45°S geomagnetic) at the altitude of observation (475 g/cm<sup>2</sup>). However, comparison of data from two fixed stations, Lae (16°S geomagnetic) and Hobart (52°S geomagnetic), showed that this latitude independence did not extend to sea level. (PA, v. 62, #4768)



**325. UNUSUAL COSMIC-RAY INTENSITY**

**FLUCTUATIONS OBSERVED AT SOUTHERN STATIONS DURING OCTOBER 21st-24th, 1957**

McCracken, K. G. and Parsons, N. R.

*Physical Review, The*, v. 112, no. 5, pp. 1798-1801, December 1, 1958

Observations are reported from four southern stations. These fluctuations exhibit unusual features which suggest the existence of a short-lived and highly directional anisotropy of the primary radiation during the period immediately preceding a Forbush-type decrease. (PA, v. 62, #2474)

**326. VARIATIONS IN THE COSMIC-RAY NUCLEONIC INTENSITY**

Lockwood, J. A.

*Physical Review, The*, v. 112, no. 5, pp. 1750-1758, December 1, 1958

The monthly mean intensity of the nucleonic component of cosmic radiation measured at Mt. Washington, geographic latitude 44.2°N and elevation 6262 ft, decreased 22 percent from July 1954 to December 1957. The decreased intensity now prevailing came about through a series of sudden decreases from which only partial recovery occurred. During this same period, the amplitude of the day-to-day intensity changes has increased. A study has been made of the largest Forbush-type decreases which have occurred in this interval. Many of these intensity drops have a decrease rate  $\sim 1.5$  percent  $\text{hr}^{-1}$ , with a maximum rate of 2.5 percent  $\text{hr}^{-1}$ . In some cases they are preceded by a slight increase of  $\sim 1.5$  percent. These decreases do not have a similar time dependence. There is no apparent 27-day recurrent tendency for these sudden drops. The energy dependency of these events is variable. The restrictions which these decreases impose upon the existing models of solar modulation mechanisms are discussed. (PA, v. 62, #3621)

**327. SOME MEASUREMENTS OF ATMOSPHERIC NEUTRONS**

Gabbe, J. D.

*Physical Review, The*, v. 112, no. 2, pp. 479-502, October 12, 1958

A series of airplane flights carrying neutron counters to an altitude of 700 g/cm<sup>2</sup> was made at 52°20' north geomagnetic latitude in 1955. Enriched and normal BF<sub>3</sub>

counters were covered with Cd, Sn, Pyrex, and lime-glass shields. The ratios of the counting rates of the variously shielded counters are compared with the ratios calculated theoretically on a thick-shield basis using the neutron energy distribution function derived by Freese and Meyer (1953). The neutron-production data taken by Davis (1951) and by Staker (1951) with Pyrex-glass-envelope BF<sub>3</sub> counters are corrected for the absorption of neutrons by the boron in the Pyrex. The corrected neutron-production rates are recalculated to be  $2.1 \pm 0.4 \text{ cm}^{-2} \text{ sec}^{-1}$  and  $0.9 \pm 0.2 \text{ cm}^{-2} \text{ sec}^{-1}$  at 54°36' and 30°24' north geomagnetic latitude, respectively, using recent values for the various neutron cross-sections. These corrected rates agree, to within 5 percent, with the recent measurements reported by Soberman. The above energy distribution function was found, within the limited accuracy of the experiment, to describe the energy distribution of atmospheric neutrons. (PA, v. 62, #4771)

**328. ABUNDANCE OF LIGHT NUCLEI IN THE PRIMARY COSMIC RADIATION**

Appa Rao, M. V. K., Biswas, S., Daniel, R. R.,

Neelakantan, K. A., and Peters, B.

*Physical Review, The*, v. 110, pp. 751-765, May 1, 1958

The composition of the primary cosmic radiation is modified as a result of nuclear collisions which particles suffer in transit through the interstellar medium. The most sensitive indicator for the frequency of such collisions is the number of nuclear fragments corresponding to lithium, beryllium, and boron, which are found in the incident radiation close to the top of the atmosphere. It is, however, difficult to determine what fraction of these particles originated in outer space and what fraction is due to additional nuclear collisions in the uppermost layers of the atmosphere above the point of observation. In order to determine the relative importance of these two components, the percentage of light elements in the primary cosmic radiation was measured as a function of the amount of air traversed by the particles. Measurements are based on an analysis of 651 particle tracks recorded at geomagnetic latitude  $\lambda$  41°. The relative intensities obtained under air masses varying from 8.5 to 30 g/cm<sup>2</sup> are in good agreement with individual values for vertically incident particles obtained by other workers. Data were obtained at a rather great altitude (6.6 g/cm<sup>2</sup> of residual pressure), so that they permit an extrapolation

to the top of the atmosphere which is largely independent of assumptions regarding the collision cross sections and fragmentation probabilities of complex nuclei. The following primary flux values, in particles/m<sup>2</sup> sec sterad, were obtained:

Li, Be, B ( <i>L</i> nuclei)	$0.55 \pm 0.60$
C	$2.65 \pm 0.40$
N	$1.90 \pm 0.35$
O, F	$3.00 \pm 0.45$
C, N, O, F, ( <i>M</i> nuclei)	$7.55 \pm 0.65$
$Z \geq 10$ ( <i>H</i> nuclei)	$2.20 \pm 0.35$

Thus Li, Be, and B nuclei represent but a small fraction of the flux of heavy primary particles. In order to account for this composition, the amount of interstellar gas traversed by the particles since their initial acceleration cannot have exceeded 1 g/cm<sup>2</sup> of hydrogen, as will be shown in detail in a separate paper. The smallness of this value imposes very stringent conditions on acceptable theories for the acceleration and subsequent diffusion of cosmic ray particles. (NSA, v. 12, #11,518)

### 329. CHARGE SPECTRUM, MEAN FREE PATHS, AND FLUX OF HEAVY PRIMARY COSMIC RAYS AT THE TOP OF THE ATMOSPHERE

Young, O. B. and Harvey, F. E.

*Physical Review, The*, v. 109, pp. 529–532,  
January 15, 1958

This investigation is restricted to primary cosmic rays of nuclear charges equal to or greater than ten at the geomagnetic latitude of 41°N. Data were obtained from thick emulsions exposed at high altitudes over Texas. The flux, extrapolated to the top of the atmosphere, was found to be  $2.65 \pm 0.3$  particles/m<sup>2</sup> sec sterad. The distribution histogram for the charge spectrum is included. The attenuation mean free paths for three groups were  $28.5 \pm 2.8$ ,  $26.7 \pm 2.9$ ,  $23.6 \pm 3.7$  g/cm<sup>2</sup> for  $Z = 10$ –11, 12–14, 15–26, respectively. (NSA, v. 12, #5429)

### 330. COSMIC-RAY CHANGES FROM 1954 TO 1957

Neher, H. V. and Anderson, H.

*Physical Review, The*, v. 109, no. 2, p. 608,  
January 15, 1958

It is deduced, from comparison of data obtained with ionization chambers flown in balloons, that the flux of cosmic ray particles near the top of the atmosphere at Thule, Greenland decreased by a factor of 4, between August 1954, sunspot minimum, ( $0.24$  particles cm<sup>-2</sup> sec<sup>-1</sup> sterad<sup>-1</sup>) and August 1957, sunspot maximum ( $0.056$  particles cm<sup>-2</sup> sec<sup>-1</sup> sterad<sup>-1</sup>). (PA, v. 61, #2384)

### 331. GEOMAGNETIC EFFECTS ON HEAVY PRIMARY COSMIC RADIATION AT 42°N

Danielson, R. E. and Freier, P. S.

*Physical Review, The*, v. 109, pp. 151–157,  
January 1, 1958

The zenith and azimuthal angular distribution of primary cosmic rays with charges  $Z \geq 5$  has been measured at Texas using horizontal emulsions with known orientation relative to the Earth. The magnitude of the azimuthal asymmetry is consistent with Störmer theory down to a zenith angle of about 65° while for larger zenith angles the effect of the solid Earth (shadow cone) is observed. The direction of the asymmetry seems to be consistent with the centered dipole approximation of the Earth's magnetic field (north pole at 79°N and 70°W). The flux at the top of the atmosphere is  $1.6 \pm 0.3$  particles/m<sup>2</sup> sec sterad for nuclei with  $Z \geq 10$  and  $4.8 \pm 1.0$  particles/m<sup>2</sup> sec sterad for CNO and F nuclei. (NSA, v. 12, #4268)

### 332. DIRECT OBSERVATION OF PERIODIC VARIATION OF PRIMARY COSMIC-RAY INTENSITY

Pomerantz, M. A., Agarwal, S. P., and Potnis, V. R.

*Physical Review, The*, v. 109, no. 1, pp. 224–225,  
January 1, 1958

It is stated that a periodic variation in cosmic ray intensity near the top of the atmosphere has been measured with balloon-borne quadruple coincidence counter trains, during the maximum phase of the solar cycle, and that the flux sometimes decreases to as much as 25 percent below normal intensity during this period. (PA, v. 61, #2383)

### 333. INITIAL STAGES IN THE PROPAGATION OF COSMIC RAYS PRODUCED BY SOLAR FLARES

Lüst, R. and Simpson, J. A.

*Physical Review, The*, v. 108, pp. 1563–1576,  
December 15, 1957

The propagation of solar cosmic rays produced in the February 23, 1956 flare has been studied from the time they leave the flare region to the time when the terrestrial cosmic ray intensity reaches a maximum value. Within this interval there are observed not only strong anisotropies in the incident radiation, but also relatively large differences in time ( $\leq 9$  minutes) between the commencements of the intensity increases in different parts of the world. The distribution of time delays is superposed upon the transit-time delay which all particles experience between production and detection. From these experimental results, and the calculations of orbits connecting the Sun and Earth at the time of the flare, it is shown that there are broad impact zones on the Earth within the first ten minutes of the cosmic ray intensity increases. Using the recently deduced flare-particle spectrum, cosmic ray intensities at the top of the atmosphere have been determined for the different impact zones. For this flare event the "2000 hour" impact zone becomes as important as the "0900" and "0300" hour impact zones. These results demonstrate that the first flare particles arriving at the Earth were not of low energy, and that the low-energy particles arrived later—the delay being an inverse function of energy. This energy-dependent spread of first arriving particles is called the dispersion effect arising from the mode of particle propagation from the flare source to the Earth. These conclusions show that back scattering from disordered magnetic fields beyond the orbit of the Earth does not account for the time delays. Various alternatives are considered for production of this distribution of onset times. The most likely process appears to be propagation through magnetic fields by diffusion. Since the impact-zone data for all geomagnetic latitudes, including both polar regions, predict a distant source in the direction of the Sun but of order one radian solid angle in the sky, and since sufficient diffusion around the Earth to produce the required time delays would destroy the observed impact-zone effects, it is suggested that there may exist a diffusing envelope around the Sun which accounts for both the apparent source size and the dispersion effect. Small irregularities in the general solar dipole field are invoked to produce the diffusion. Calculations show that the predicted dispersion effect agrees with the observations, and that other details following from diffusion are satisfied. There is evidence of a dispersion effect for the flare par-

ticles of November 19, 1949. The implications of these results for possible uniform magnetic-field distributions between the Sun and Earth are reviewed, and it is shown from the orbit calculations and the dispersion effect that the predictions are not in agreement with observations. There is a transition period between the time when impact zones are dominant and the time when isotropy sets in. The subsequent storage of the solar cosmic ray particles is not further considered in this paper, except for the bearing of these observations at early times upon the character of the interplanetary storage magnetic fields. (NSA, v. 12, #4879)

### 334. POLARIZATION OF COSMIC-RAY $\mu$ MESONS: EXPERIMENT

Clark, G. W. and Hersil, J.

*Physical Review, The*, v. 108, no. 6, pp. 1538–1544, December 15, 1957

Describes an experimental determination of the polarization of low-energy cosmic ray  $\mu$ -mesons at sea level. A brass plate was placed in a horizontal position inside a magnetic solenoid. Particles which arrived from directions near the vertical and stopped in the plate were detected by a coincidence-anticoincidence counter telescope. Stopped negative  $\mu$ -mesons were destroyed by nuclear capture. Stopped positive  $\mu$ -mesons decayed into electrons which were detected by delayed coincidence counters placed above and below the plate. The upward and downward fluxes of the decay electrons leaving the absorber were measured alternately with and without a depolarizing magnetic field. The results of the measurements demonstrate that: (1) cosmic ray  $\mu$ -mesons are polarized; (2) the ratio between the downward fluxes of electrons from the decay of  $\mu$ -mesons stopped in a brass plate with and without a depolarizing magnetic field is  $1.052 \pm 0.016$ , and (3) the indicated polarization of stopped positive  $\mu$ -mesons is  $0.19 \pm 0.06$  if the data are interpreted according to the two-component neutrino theory of  $\mu$ -meson decay. The results are consistent with theoretical predictions based on the production spectrum of  $\pi$ -mesons as found in other experiments. (PA, v. 61, #1750)

### 335. HIGH-ALTITUDE INTENSITIES OF THE MEDIUM AND HEAVY COSMIC-RAY NUCLEI AND OF THE STAR-PRODUCING COMPONENT OVER A 25-HOUR INTERVAL

Missert, R. F.

*Physical Review, The*, v. 108, pp. 1327-1330,  
December 1, 1957

Results are reported on a study of the hourly averaged values of intensity of medium and heavy cosmic ray nuclei and of the star-producing component over a day and night interval, at an average atmospheric depth of 15 g/cm<sup>2</sup>. The equipment was carried aloft by a Skyhook balloon on August 6, 1954 from Minneapolis, Minnesota (geomagnetic latitude 55°N). A large, thin-walled spherical pulse-ionization chamber served as the detecting instrument. Approximately 125,000 of these cosmic ray events were recorded over the 25-hour flight interval; thus, statistical counting rate fluctuations were reduced substantially below those previously attained in this field. Analysis shows that approximately one-half of the counting rate at 15 g/cm<sup>2</sup> can be ascribed to the medium and heavy nuclei, the remainder being reasonably accounted for as arising from the star-producing component. No variation is observed in the hourly averaged counting rate of pulses of size greater than 6 Mev throughout the flight, to within the combined statistical and experimental uncertainties of  $\pm 4$  to 6 percent during the daytime, and  $\pm 8$  to 10 percent during the night. (NSA, v. 12, #4267)

**336. RARE HIGH-ENERGY PHOTON JET IN COSMIC RAYS**

Young, O. B. and Yoon, T. S.

*Physical Review, The*, v. 108, no. 3, pp. 908-909,  
November 1, 1957

An event, consisting of seven electron pairs in an emulsion stack, is described. The energies of these pairs range from 126 to 3630 Mev, and total nearly 11 Bev. The photons do not materialize at the same distance from some common origin; there is no evidence that materialization depends upon energy. The axis zenith angle is 98°, indicating that the source is a nuclear interaction at lower altitude than the balloon. The photon jet is very narrow; the half-angle of the cone enclosing all particles is less than 0.001 radian. (PA, v. 61, #2380)

**337. LARGE AURORAL EFFECT ON COSMIC-RAY DETECTORS OBSERVED AT 8 g/cm<sup>2</sup> ATMOSPHERIC DEPTH**

Winckler, J. R. and Peterson, L.

*Physical Review, The*, v. 108, no. 3, pp. 903-904,  
November 1, 1957

A large increase in the counting rates of a single Geiger counter and an ionization chamber was observed during an intense auroral display, at 8 g/cm<sup>2</sup> atmospheric depth above Minneapolis on July 1, 1957. Information concerning the type of radiation responsible for the increase is obtained from the ratio of counting rates in ion chamber and counter (which was 1.3-1.4 during the burst excess, compared with 0.26 at the same altitude, prior to the increase); the increase could be due to protons with  $\beta \cong 0.45$  at the top of the atmosphere, or to  $\sim 60$  kv X-rays, emitted as bremsstrahlung from electrons with  $\beta \cong 0.5$ . This implies the presence in the auroral beam of particles much greater in velocity than the beam itself. (PA, v. 61, #5085)

**338. HIGH-ALTITUDE COSMIC-RAY LATITUDE EFFECT FROM 51° TO 65°N GEOMAGNETIC LATITUDE**

Winckler, J. R. and Anderson, K. A.

*Physical Review, The*, v. 108, pp. 148-154,  
October 1, 1957

A significant latitude effect of approximately 45 percent for the total vertical cosmic ray flux has been found over the region 51°N to 65°N at 10 g/cm<sup>2</sup> atmosphere depth in 1955. No evidence for a primary "knee" can be found separated from the air-path saturation effect with latitude. Since there is evidence that the  $\alpha$  spectrum is flat north of 55°, one concludes that the rigidity spectra of primary protons and  $\alpha$ 's differ over the corresponding rigidity region. Comparison of these data with telescope measurements of Pomerantz and McClure in 1950 does not show the anticorrelation with sunspot numbers found by Neher for ion-chamber measurements. The data are not in disagreement with latitude coordinates 4° higher suggested by studies of  $\alpha$  particles, and, in fact, the observed latitude "saturation" effects are in better agreement with these new coordinates. A greatly increased counting rate was observed both at Minneapolis and Flin Flon, Manitoba, on August 26, 1955 at high altitude. (NSA, v. 12, #1462)

**339. MEAN FREE PATH OF HIGH-ENERGY NUCLEONS IN THE ATMOSPHERE**

Farrow, L. A.

*Physical Review, The*, v. 107, pp. 1687-1694,  
September 15, 1957

An altitude-variation experiment to determine the absorption mean free path in the atmosphere of high-energy nucleons of the cosmic radiation has been performed using a large ionization chamber and associated counter trays. It is estimated that the nucleons studied in this experiment range in energy from 200 to 2000 Bev, which is a higher energy region than has been investigated previously in similar experiments. The absorption mean free path for protons is found to be  $125 \pm 9$  g/cm<sup>2</sup> and for neutrons  $105 \pm 8$  g/cm<sup>2</sup>, and the charged to-neutral ratio is  $1.54 \pm 0.15$ . These values are in good agreement with previous altitude variation experiments. There seems to be no change in the mean free path with energy. These results are compared with the calculations of Olbert and Stora, who consider the Fermi model for nuclear interactions with the assumption of no nucleon-antinucleon pair production and partial elasticity for the collision. It is seen that the experimental values fit fairly well into this picture. Evidence is presented for the presence of high-energy nucleons near the cores of air showers, in agreement with previous work. If a power law is fitted to the density spectrum of air showers associated with nucleons, a crude value of 0.64 may be found for the exponent. Considering the scarcity of the data on which the evaluation of this particular quantity is based, the result may be in reasonably good agreement with the only previous determination which is equal to 0.5. (NSA, v. 12, #341)

**340. UNUSUAL COSMIC-RAY FLUCTUATIONS  
ON JULY 17 AND 18, 1959**

Carmichael, H. and Steljes, J. F.

*Physical Review Letters*, v. 3, no. 8, pp. 392-394,  
October 15, 1959

A large Forbush decrease of cosmic ray intensity which coincided with a magnetic storm exhibited rapid changes of neutron intensity, at the rate of 7 percent in 20 minutes. It is difficult to account for these changes on the basis of existing theories of the modulation of cosmic radiation.

**341. FURTHER OBSERVATIONS ON THE  
NATURE OF THE CURRENT REDUCTION  
IN THE PRIMARY COSMIC RAY INTENSITY**

Pomerantz, M. A. and Agarwal, S. P.

*Physical Review Letters*, v. 1, no. 3, pp. 107-109,  
August 1, 1958

Balloon-borne pulsed ionization chambers were biased to respond principally to nuclear disintegrations produced by fast protons and neutrons, and heavy nuclei with  $Z > 8$ . The results indicate that the flux of heavy nuclei and high-energy protons did not change at a time when the total intensity (measured by a balloon-borne vertical quadruple coincidence counter train containing 7.5 cm of lead) had decreased by  $\sim 23$  percent; this implies that the current reduction in primary cosmic ray intensity is a consequence of a change in the cutoff rigidity only. It is suggested that a sharp cutoff of protons, unaccompanied by a corresponding cutoff of heavy nuclei, could be explained by ascribing the observed decrease in primary intensity to the action of a cutoff mechanism at the Sun, upon low energy cosmic rays of solar origin. (PA, v. 62, #1569)

**342. COSMIC-RAY INCREASES PRODUCED BY  
SMALL SOLAR FLARES**

Corrigan, J. J., Singer, S. F., and Swetnick, M. J.

*Physical Review Letters*, v. 1, pp. 104-105,  
August 1, 1958

An experiment was designed to detect short-lived or small increases in the low-energy component of total cosmic ray intensity, observe the structure, and study the correlation in time with small solar flares. The first observations of two unusually short-lived increases in the low-energy portion of cosmic rays measured at latitude 55° geomagnetic and altitude 45,000 ft are reported. The increases were 30 percent and lasted for two and three minutes. (NSA, v. 12, #13,214)

**343. ON THE ANALYSIS OF THE SLOW  
PARTICLES EMITTED FROM COSMIC-RAY  
STARS. II**

Nakagawa, S., Tamai, E., Huzita, H., and  
Okudaira, K.

*Physical Society of Japan, Journal of the*, v. 12,  
no. 7, pp. 747-752, July 1957

(For Part I see PA, v. 59, #3814). Observations were made on the heavy fragments from stars produced by cosmic rays and 6.2 Bev protons from bevatrons. The charges of the heavy fragments were determined by measuring the width of tracks. The charge distribution of the

heavy fragments emitted from silver or bromine nuclei seems approximately to decrease exponentially. The energy distributions of lithium and beryllium nearly agreed with the curves deduced from the evaporation model, assuming the appropriate nuclear temperatures and Coulomb barrier heights. The angular distributions of them were nearly isotropic. According to these results, the process of slow fragment emission seems to be interpreted as that of evaporation. (PA, v. 61, #8103)

**344. THE ABSOLUTE INTENSITIES OF COSMIC RAYS AT 2840 METERS AND GEOMAGNETIC LATITUDE 25°N**

Murakami, M. and Maeda, T.

*Physical Society of Japan, Journal of the*, v. 12, no. 5, p. 557, May 1957

Intensities of the total, hard and soft components of cosmic rays are given as  $2.07 \pm 0.02$ ,  $1.17 \pm 0.01$  and  $0.90 \pm 0.02$ ,  $\times 10^{-2} \text{ cm}^{-2} \text{ sec}^{-1} \text{ sterad}^{-1}$  respectively, using the technique of measurement reported by Kitamura and Minakawa (PA, v. 57, #6715). The zenith angle distribution of intensities between  $0^\circ$  and  $45^\circ$  is given by  $\cos^{2.1} \theta$  and  $\cos^{3.1} \theta$  for the hard and soft components respectively. The ratios of intensities at 2840 m and sea level, at different zenith angles, for the total, hard and soft components are also reported. (PA, v. 61, #4106)

**345. DISTRIBUTION OF K-MESONS PRODUCED IN HIGH ENERGY NUCLEAR INTERACTIONS**

Biswas, S. N.

*Physical Society, Proceedings of the*, London, v. 72, Part 2, pp. 169-181, August 1958

As an example of the application of the K-meson production cross section the K-meson component is considered in the extensive air showers. A cascade theory of the cosmic ray shower was developed embracing the fact that the heavy mesons and hyperons cascade in the nucleus in a manner analogous to the pions and nucleons. Numerical results for the nucleons, pions, hyperons and the K-meson components in the longitudinal development of the cosmic ray air shower were presented and compared with available experimental data. (PA, v. 61, #8087)

**346. IONIZING RADIATION DETECTED BY PIONEER II**

Rosen, A., Coleman, P. J., Jr., and Sonett, C. P.

*Planetary and Space Science*, v. 1, no. 4, pp. 343-346, September 1959

**347. STUDY OF THE COSMIC-RAY SOFT COMPONENT BY THE 3rd SOVIET EARTH SATELLITE**

Vernov, S. N., Chudakov, A. E., Gorchakov, E. V., Logachev, J. L., and Vakulov, P. V.

*Planetary and Space Science*, v. 1, no. 2, pp. 86-93, April 1959

**348. COSMIC-RAY STUDIES BY MEANS OF ARTIFICIAL EARTH SATELLITES**

Dobrotin, N. A.

*Priroda* (in Russian), v. 48, no. 1, pp. 57-64, January 1959

The data obtained from instruments installed in artificial satellites produced important information on the cosmic ray primary emissions and the characteristics of the Earth's magnetic field. The discovery of the new phenomenon of the intensive "aureole" of particles around the Earth is of great significance. The cosmic ray intensity variations in relation to distance from the Earth and the relation of the particle number to geomagnetic latitude, as well as the cosmic ray recordings of two counters in the second satellite, are plotted. A graph showing the gas discharge counter performance in equatorial regions at various elevations is included. (NSA, v. 13, #10,348)

**349. THE THIRD SOVIET ARTIFICIAL EARTH SATELLITE. INVESTIGATION RESULTS ON THE INTENSITY OF COSMIC RADIATION**

Kurnosova, L. V.

*Priroda* (in Russian), v. 6, pp. 85-86, 1958

Variations in the cosmic radiation intensity showed that at the 700 km altitude the intensity increases about 40 percent in comparison to the intensity at 200 km. The number of recorded particles changes slowly with greater distances from the Earth. At 1500 km the increase in intensity is about 15 percent. Data on the particle num-

ber dependence on longitude and latitude indicate that the lines of cosmic ray intensity do not coincide with geomagnetic lines. (NSA, v. 12, #15,635)

**350. RATIO OF HYPERONS PRODUCED BY COSMIC RAYS**

Hsieh, S. H.

*Progress of Theoretical Physics, Kyoto*, v. 18, pp. 209-210, August 1957

Experimental results on hyperon production by cosmic rays and the estimated production ratios of hyperons are discussed. It is shown that these production ratios are not inconsistent with those given by Landau-Beleñkiis'. (NSA, v. 12, #5431)

**351. SOME RESULTS ON THE TIME VARIATION OF THE HEAVY COMPONENT OF PRIMARY COSMIC RAYS**

Barford, N. C., Davis, C., Castagnoli, C., Franzinetti, C., and Manfredini, A.

*Ricerca Scientifica, La*, v. 26, no. 10, pp. 3061-3066, October 1956

An experiment is described, which was planned to measure the flux of heavy, primary cosmic rays and to investigate its time variation. The experiment was carried out by exposing nuclear emulsions at high altitudes by means of balloons. The value of the flux obtained is in agreement with that of other experiments at the same latitude. The results give no evidence for any change in flux during the course of the exposure. (PA, v. 61, #6021)

**352. EXTRA-ATMOSPHERIC COSMIC RAY DOSAGE DURING THE LARGE SOLAR FLARE OF 23 FEBRUARY 1956**

Schaefer, H. J.

*Science*, v. 127, pp. 186-187, January 24, 1958

For a geomagnetic cutoff latitude of  $52^\circ$ , with an integral extra-atmospheric flare-dose of  $\sim 1.5$  rad units, the polar region dosage from primary protons would have been just below the danger level. Other ionizing radiations would have increased the level significantly. (PA, v. 61, #3215)

**353. ALTITUDE-VARIATION OF COSMIC RAY STARS**

Shimizu, K.

*Science Reports of the Research Institutes, Tôhoku University, First Series*, v. 40, no. 4, pp. 224-232, January 1957

The star frequency of cosmic rays was measured using nuclear emulsions exposed at several altitudes between sea level and 3776 m and its altitude-variation is obtained. Star-size distributions were also considered, the contributions from the light and heavy nuclei contained in the emulsion being studied, and the mean propagation of  $\alpha$ -particles appearing in the stars measured. (PA, v. 61, #6022)

**354. LOGARITHMIC REPRESENTATION OF COSMIC-RAY INTENSITY**

Wada, M.

*Scientific Research Institute, Journal of the, Tokyo*, v. 51, pp. 201-210, December 1957

To evaluate the quantities which indicate the variational amounts relative to the mean of cosmic ray intensity, the use of their natural logarithms is examined. While a standard unit is required for the relative intensity when represented by ordinary percentage value, it is not needed for the logarithmic indication. Several advantages due to the use of logarithms are described. (PA, v. 61, #2382)

**355. CUT-OFF RIGIDITIES OF COSMIC-RAY PARTICLES CALCULATED FOR THE ECCENTRIC DIPOLE MODEL OF THE EARTH'S MAGNETIC FIELD**

Kodama, M., Kondo, I., and Wada, M.

*Scientific Research Institute, Journal of the, Tokyo*, v. 51, pp. 138-157, September 1957

Magnetic cutoff rigidities of cosmic ray particles falling from zenith are calculated for the eccentric dipole model of the Earth's magnetic field. The difference between the distances of the point of observation from the magnetic and geographic centers, actual magnetic latitude, and the angle between verticals referred to the two centers are considered as the quantities for correcting the rigidities calculated for the centered dipole field. Tables of numerical results together with contour maps are presented for

the points along the geographic latitudes from 70°N to 70°S in 10° intervals, with the longitude intervals of 15°. Comparisons of results of similar calculations by several workers are performed. It is shown that rigidities derived from Johnson's map are greater than the present results up to 3 Bev in the middle latitudes. (NSA, v. 12, #2986)

**356. COMPARISON OF COSMIC-RAY INTENSITY VARIATIONS OBSERVED AT DIFFERENT ALTITUDES**

Miyazaki, Y.

*Scientific Research Institute, Journal of the, Tokyo*, v. 51, pp. 97-106, September 1957

Simultaneous registrations of the cosmic ray meson component have been made at sea level and at mountain altitude of almost the same geomagnetic latitudes and longitudes. The time variation of comparatively low energy side of the primary cosmic radiation could be derived by the comparison of the intensity variations observed at different altitudes. (NSA, v. 12, #2985)

**357. ON THE LATERAL DISTRIBUTION OF PARTICLES IN AN ELECTRON-PHOTON SHOWER**

Guzhavin, V. V. and Ivanenko, I. P.

*Soviet Physics-JETP*, v. 2, pp. 407-411, July-August 1957

**358. THE LARGE COSMIC RAY BURST OF FEBRUARY 23, 1956 AS OBSERVED AT MOSCOW, SVERDLOVSK, TBILISI AND CAPE SCHMIDT**

Dorman, L. I., Kaminer, N. S., Koiava, V. K., and Shvartsman, B. F.

*Soviet Physics-JETP*, v. 1, pp. 364-366, May-June 1956

**359. AN UNUSUAL COSMIC RAY BURST**

Kuz'min, A. I., Skrypin, G. V., Tianutova, G. V., and Shafer, Iu. G.

*Soviet Physics-JETP*, v. 1, pp. 263-265, May-June 1956

On February 23, 1956 at 3:45 Greenwich time in the town of Yakutsk, three instruments of the Cosmic Radia-

tion Laboratory recorded a flash of cosmic rays of great intensity. The ionization chambers recorded a 200 percent increase from the mean value. Crossed counter telescopes recorded an increase of the same magnitude. The Earth remained quiet and only rare pulsation of H compounds were observed. Atmospheric pressure remained unchanged but there was a sudden 10-deg temperature increase. At 4:00 o'clock Greenwich time, the ionization station in Yakutsk recorded complete radiowave absorption in the 2- and 7-megacycle bands. During the flash all radio communications were interrupted in Yakutsk territory. This ionospheric disturbance was due to an unprecedented chromospheric explosion on the Sun. Previously recorded flashes were much weaker. A 200 percent increase in intensity of cosmic rays along the vertical and the considerable influx of cosmic radiation from the south, as well as the analysis of other data indicated that the intensity flash was induced by particles of  $10^9$  to  $10^{10}$  ev, which originated on the Sun. (NSA, v. 10, #11,263)

**360. INVESTIGATION OF PION PRODUCTION IN INTERACTIONS OF COSMIC-RAY PROTONS AND  $\alpha$ -PARTICLES WITH CARBON NUCLEI IN THE STRATOSPHERE**

Alekseeva, K. I., Briker, S. I., Grigorov, N. L., Murzin, V. S., and Savin, F. D.

*Soviet Physics-JETP*, v. 37, no. 3, pp. 422-427, March 1960

Pulse ionization chambers and a hodoscope were used to study the interaction of primary protons and particles with carbon nuclei in the stratosphere at 31°N geomagnetic latitude.

**361. PRODUCTION OF K<sup>+</sup>MESONS BY COSMIC-RAY PROTONS AT 3250 m ABOVE SEA LEVEL**

Balats, M. Ya., Lebedev, P. I., and Obakhov, Yu. V.

*Soviet Physics-JETP*, v. 37, no. 3, pp. 417-421, March 1960

The spectrum of K<sup>+</sup> mesons in the momentum range up to 0.9 Bev/c produced by cosmic ray protons was measured at an altitude of 3250 m above sea level (Mt. Alagez). The cross section for this process is estimated.



**362. MOMENTUM SPECTRUM OF PARTICLES OF THE HARD COMPONENT OF COSMIC RAYS AT AN ALTITUDE OF 9 km**

Baradezi, L. T., Solov'ev, M. V., Tulinova, Z. I., and Filatova, L. I.

*Soviet Physics-JETP*, v. 36, no. 6, pp. 1151-1154, December 1959

Measurements of the momentum spectrum of particles of the hard component of cosmic rays at an altitude of 9000 m were carried out, using a cloud chamber in a magnetic field.

**363. SMALL EFFECTS OF SOLAR FLARES AND THE ENERGY SPECTRUM OF PRIMARY VARIATION OF COSMIC RAYS**

Kolomeets, E. V.

*Soviet Physics-JETP*, v. 36, no. 9, pp. 960-962, November 1959

The relation between the intensity of cosmic ray neutrons and chromospheric flares on the Sun was studied from the data obtained at four stations located at various latitudes.

**364. HIGH-ENERGY NEUTRONS IN COSMIC RAYS**

Flerov, G. N., Kalashnikova, V. I., Podogurskaya, A. V., Vorob'ev, E. D., and Stolyarov, G. A.

*Soviet Physics-JETP*, v. 36, no. 3, pp. 511-515, September 1959

Multiple-plate ionization chambers were used to detect the fission of heavy nuclei by cosmic rays. The altitude dependence of fission was investigated as well as the angular distribution of the fission-inducing particles.

**365. TRANSITION EFFECT OF STARS IN A LEAD ABSORBER**

Varsimashvili, T. V. and Kostanashvili, N. I.

*Soviet Physics-JETP*, v. 6, pp. 1183-1184, June 1958

The results of a control experiment undertaken in order to observe by means of photographic emulsions the transition effect for stars in lead absorbers are presented. The measurements were made at 3100 m above sea level. The

maximum of the transition effect was 30 percent. Three-fold scanning of the same volume of emulsion was used, and a sharply pronounced maximum was observed. (NSA, v. 12, #14,049)

**366. MOMENTUM SPECTRUM OF THE COSMIC RADIATION AND THE POSITIVE EXCESS IN THE  $(0.1-2.5) \times 10^9$  ev/c RANGE AT AN ALTITUDE OF 3250 m**

Vaisenberg, A. O.

*Soviet Physics-JETP*, v. 5, no. 3, pp. 352-357, October 1957

The spectrum of the hard component and the spectrum of unfiltered cosmic radiation were measured at an altitude of 3.25 km with the aid of magnetic analysis. The spectral distribution of the positive excess was obtained and the contributions of the proton and meson components to the magnitude of the excess evaluated. (PA, v. 61, #5089)

**367. SPECTRUM AND POSITIVE EXCESS OF THE HARD COMPONENT IN THE  $(0.3-17) \times 10^9$  ev/c MOMENTUM RANGE AT AN ALTITUDE OF 3250 m**

Alikhanyan, A. I. and Vaisenberg, A. O.

*Soviet Physics-JETP*, v. 5, no. 3, pp. 349-351, October 1957

The spectral distribution of the positive excess in the hard component was measured in the  $(0.3-17) \times 10^9$  ev/c momentum range. The measurements were performed on the large spectrograph of the Alagez Laboratory at an altitude of 3.25 km. (PA, v. 61, #5088)

**368. AN ANALYSIS OF SOME COSMIC RAY MESON PRODUCTION EVENTS. II**

Birger, N. G., Gusena, V. V., Kotel'nikov, K. A., Maksimenko, V. M., Riabikov, S. V., Slavatsinskii, S. A., and Stashkov, G. M.

*Soviet Physics-JETP*, v. 4, pp. 836-841, July 1957

Three cases of meson production by cosmic rays are described. In each one, the momentum of the primary particle was measured by a magnetic method using two cloud chambers. The analysis confirms the existence of a large spread in the number of secondary particles and in the energy carried away by  $\pi$ -mesons. (NSA, v. 12, #3753)

**369. ON THE MASS SPECTRUM OF CHARGED COSMIC RAY PARTICLES**

Alikhanian, A. I., Shostakovich, N. V., Dadaian, A. T.,  
Fedorov, V. N., and Deriagin, B. N.

*Soviet Physics-JETP*, v. 4, pp. 817-830, July 1957

Results of an investigation of the cosmic ray particles mass spectrum at 3200 m are reported. The measurements were carried out by means of a magnetic spectrometer used in conjunction with two cloud chambers. Protons, deuterons,  $\pi$  mesons, and  $K$  particles were observed among the particles locally generated in stars above the experimental arrangement. The cases of 11 particles with masses of about 500 to 600  $m_e$  stopping in the lower chamber are discussed. In all these events, neither a star nor a shower was observed in the upper chamber. It was found that some of these particles entered the apparatus from the outside in a similar manner to the  $\mu$ -mesons. (NSA, v. 12, #3752)

**370. THE IONIZATION SPECTRUM OF COSMIC RAYS 3250 m ABOVE SEA LEVEL**

Meshkovskii, A. G. and Sokolov, L. I.

*Soviet Physics-JETP*, v. 4, pp. 629-632, June 1957

Using a previously described method, the ionization spectra produced by the soft and hard components of cosmic rays of various ranges at 3250 m above sea level were measured. The proton momentum spectrum was obtained in the interval 0.36 to 1.0 Bev/c. (NSA, v. 12, #2992)

**371. THE NASA SPACE SCIENCES-2**

*Spaceflight*, v. 11, no. 5, pp. 143-146, January 1960

A brief account is given of research studies on the ionosphere, and energetic particles.

**372. LONG TERM CHANGES IN THE DAILY VARIATION OF COSMIC RAY INTENSITY**

Venkatesan, D. and Dattner, A.

*Tellus*, v. 11, no. 1, pp. 116-129, February 1959

Cosmic ray measurements at different stations for the period 1937-1955 are analyzed. The diurnal variation is found to be a world-wide phenomenon, thus giving the anisotropy of the primary radiation and its correlation with solar and geomagnetic activities. (PA, v. 62, #7142)

**373. ON THE INCREASE IN COSMIC RAY INTENSITY AND THE ELECTROMAGNETIC STATE IN INTERPLANETARY SPACE DURING THE SOLAR FLARE OF FEBRUARY 23, 1956**

Eckhardt, D.

*Tellus*, v. 10, no. 1, pp. 126-136, February 1958

The solar flare increase of cosmic ray intensity observed at various ionization chamber stations was studied. The orbits of the flare cosmic ray particles was corrected for their deflection in the geomagnetic field. A detailed discussion of the different onset times of the solar flare increase registered at these stations is given. These differences in onset times serve as a means to study the electromagnetic state in interplanetary space during the cosmic ray outburst. Special attention is paid to those stations which observed the earliest onset times. For one of these, Hobart, it can definitely be shown that cosmic ray particles of momenta up to around 40 Bev/c did not arrive from the direction of the Sun. The station did not lie inside one of Firor's impact zones at the beginning of the solar flare. This shows the existence of deflecting magnetic fields between the Sun and the Earth. It appears from this investigation that the cosmic ray particles which caused the earliest onset times had come from directions towards a solar beam which—according to Alfvén's beam model (1950)—would be expected to produce the large magnetic storm observed two days after the flare. A probable mechanism of trapping and guiding the flare low energy cosmic ray particles by such a beam is also discussed. (PA, v. 61, #4113)

**374. CHANGES IN AMPLITUDE OF THE 27 DAY VARIATION IN COSMIC RAY INTENSITY DURING THE SOLAR CYCLE OF ACTIVITY**

Venkatesan, D.

*Tellus*, v. 10, no. 1, pp. 117-126, February 1958

The 27-day recurrence tendency in the cosmic ray intensity was studied by the Chree method (1913) of analysis for the period of 1937-1955, using the ionization chamber records at Huancayo. The amplitude of the 27-day variation changes from year to year. The variation in the amplitude is in general agreement with the changes in solar activity as revealed by the sunspot number only for the years 1937-1946 and 1952-1955. This is in agree-

ment with the results of Meyer and Simpson for the same periods, obtained from a slightly different method of analysis. The correlation breaks down for the period 1946-1952, and this is discussed in terms of possible changes in the electromagnetic conditions in the interplanetary space during the solar cycle. (PA, v. 61, #4112)

**375. SOME REMARKS ON THE SUDDEN  
COSMIC RAY INCREASE ON FEBRUARY  
23, 1956**

Brunberg, E. A. and Eckhardt, D.

*Tellus*, v. 8, no. 4, pp. 508-512, November 1956

The north and south pointing G.M.-telescopes at Stockholm measured different cosmic ray increases during the solar flare. It is shown that this difference is due to particles of momenta greater than 10 Bev/c, which could not have traveled along straight-line paths from the Sun. (PA, v. 61, #7149)

**376. COSMIC RAYS IN THE TERRESTRIAL  
MAGNETIC DIPOLE FIELD**

Brunberg, E. A.

*Tellus*, v. 8, no. 2, pp. 215-233, May 1956

The results of scale model experiments with electron orbits in a magnetic dipole field are given in the form of diagrams on big globes. By using these globes it is possible to find the asymptotic directions of cosmic ray particle orbits as a function of momentum and direction of incidence at a cosmic ray recording station. Globes, representing 16 stations, are depicted. (PA, v. 61, #7155)

**377. EXPERIMENTAL EVIDENCE OF THE  
DIRECTIONAL COMPONENTS OF COSMIC  
RAYS**

Sandstrom, A. E.

*Tellus*, v. 8, no. 1, pp. 18-25, February 1956

It is possible to resolve the diurnal variation into two components. The first of these has its maximum at 18 hr and corresponds to the particle wind predicted in the theory by Alfvén. The amplitude ought to be constant both as a function of geomagnetic activity and as a function of time. The second component has its maximum at 12 hr. It represents the sum of the various kinds of radial

particle flow, and it ought to display variations indirectly related to geomagnetic activity. A search for experimental evidence of these components is made possible through the determination of the incidental directions of the primary particles by Brunberg and Brunberg and Dattner. An analysis of C.R. measurements from Stockholm, Nagoya, and Huancayo seems to confirm the two components and their expected properties. A very doubtful amplitude change of the 18 hr-component during major magnetic storms is not at variance with theory. The Stockholm measurements were treated by Sandström as to geomagnetic effects, those from Nagoya and Huancayo by Sekido and Kodama. A seasonal phase shift reported by the latter for geomagnetically quiet days is compared to measurements in Stockholm. If it exists at all the reported phase shift is evidently due to local effects. Other secular or seasonal phase shifts have not been treated in the present study, as the data did not provide any example of these effects. Several points are open to discussion because of the data's being collected with instruments of widely different properties. Directional counter telescopes offer the most valuable results, if they are designed for a comparatively small aperture and measure in at least two directions. (PA, v. 61, #7147)

**378. SCANDIUM-45 AS THE REACTION  
PRODUCT OF COSMIC RADIATION IN  
IRON METEORITES. I**

Wänke, H.

*Zeitschrift für Naturforschung (in German)*,  
v. 13a, pp. 645-649, August 1958

By means of neutron activation analysis, the scandium content of three iron meteorites were measured. The amount of scandium found is approximately  $10^{-9}$  g Sc/g and was shown to be proportional to the  $\text{He}^3$ ,  $\text{He}^4$ , and Ne formed by cosmic radiation. Therefore the conclusion could be drawn that this quantity of scandium was formed for the most part by the effect of cosmic radiation on the atomic nuclei of the meteorite. The absolute concentration of scandium was compared with the reaction products of cosmic radiation previously measured in meteorites. The scandium content of a stone meteorite (Pultusk) was measured using the same methods. The value found of  $5 \times 10^{-6}$  g Sc/g agrees well with other measurements made in stone meteorites. (NSA, v. 12, #17,496)

**379. ON THE INCREASE IN COSMIC RADIATION  
ON 23 FEBRUARY 1956**

Pfeiffer, U.

*Zeitschrift für Naturforschung* (in German),

v. 12a, no. 6, pp. 513-514, 1957

An over-all increase in the strength of cosmic radiation, at Göttingen, on February 23, 1956, was detected and analyzed by a suitably shielded arrangement of coincidence counters. Preliminary analysis of the primary particles and correlation with the secondaries indicate that the flux of heavy particles was 32 percent above normal, and that of light particles, 50 percent. (PA, v. 62, #2475)

**380. ABSORPTION ANALYSIS OF THE STAR-  
PRODUCING COMPONENTS OF COSMIC  
RAYS. II. NUCLEAR PROCESSES IN  
NUCLEAR RESEARCH PLATES**

Rössle, E. and Schopper, E.

(TT-745) National Research Council of Canada,  
Ottawa, Ontario

Translated by Sinclair, D. A., from *Zeitschrift für  
Naturforschung* (in German), v. 9A, pp. 836-851,  
1954 (38 pp.)

In earlier investigations of the absorption behavior of the star-producing components in carbon, iron, and lead absorbers with nuclear research emulsions, transition effects were noted which showed distinct star frequency maxima. These results were supplemented by various measurements in iron and tin, and various absorber shapes in carbon were tested. The observed maxima consisted entirely of neutral-initiated maxima of the  $O_n$  type. Difficulties are encountered in attempting to interpret these results in terms of simple mechanisms involving known particles: the transition effects are calculated for nucleons and high-energy  $\pi$ -mesons. With regard to the maxima, no agreement with the experiment is found under the assumptions made for the calculation. In the case of photons, a new calculation of the cascade in lead carried out by Kuhn did not result in any increase of photons capable of star production leading to a maximum. There are arguments of an experimental kind against any participation of  $\mu$ -mesons. (NSA, v. 12, #13,209)

**381. ABSORPTION ANALYSIS OF THE STAR-  
PRODUCING COMPONENTS OF COSMIC  
RAYS. III. SCINTILLATION COUNTER  
MEASUREMENTS**

Kuhn, G. and Schopper, E.

(TT-746) National Research Council of Canada,  
Ottawa, Ontario

Translated by Sinclair, D. A., from *Zeitschrift für  
Naturforschung* (in German), v. 9A, pp. 851-855,  
1954 (14 pp.)

Transition curves are measured in solid absorbers with an arrangement of scintillation counters using an NaI phosphor of 40 mm diameter and 20 mm height for various discrimination levels of the ionizing events in the phosphor. The transition curves in lead, iron, and carbon absorbers in every case show two maxima, as has been observed with photographic plates. (NSA, v. 12, #11,513)

**382. BROADENING EFFECT OF THE NUCLEON  
AND MESON COMPONENTS OF COSMIC  
RADIATION AT SEA LEVEL IN THE  
INDIAN AND ATLANTIC OCEANS**

Skorka, S.

*Zeitschrift für Physik*, (in German), v. 151,  
pp. 630-645, 1958

During a voyage from Europe to Australia the cosmic radiation intensity was measured. The broadening effect of the nucleon component was 1.78 in the Atlantic and 1.99 in the Indian Ocean. The corresponding values of the meson component are 1.13 and 1.16. The deviations of the spatial intensity distribution from that expected from the eccentric Earth dipole and the good agreement of the measurements with the earlier measurement of Rose, et al., (*Canadian Journal of Physics*, v. 34, p. 968, 1956) were noted. (NSA, v. 12, #15,636)

**383. MEASUREMENTS OF MASS OF COSMIC  
PARTICLES UNDERGROUND**

Daion, M. I. and Potapov, L. I.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 36, pp. 921-922, March 1959

Results are presented of particle mass measurements made with a magnetic spectrometer which simultaneously measured the pulse spectra and the positive excess of  $\mu$ -mesons at a depth equivalent to  $\sim 40$  m of water. (NSA, v. 13, #12,912)

**384. ON THE ELECTRON-PHOTON COMPONENT SPECTRUM IN WIDE ATMOSPHERIC SHOWERS**

Ivanovskaya, I. A. and Rakobolskaya, I. V.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 35, pp. 1583-1584, December 1958

**385. MEASUREMENT OF THE COSMIC-RAY INTENSITY IN THE STRATOSPHERE AT VARIOUS HEIGHTS AND LATITUDES**

Charakhchyan, A. N. and Charakhchyan, T. N.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 35, no. 5, pp. 1088-1102, 1958

Results of measurements of the altitude dependence of particles of the cosmic ray soft component possessing different ranges are presented for latitudes of  $51^\circ$  and  $31^\circ$ . The altitude dependence of electrons of a given energy is computed on the basis of the energy spectrum of  $\mu$ -meson production in the atmosphere. The results of the calculations are in good agreement with the results of measurements performed at the latitude of  $31^\circ$  which indicates that the overwhelming majority of particles of the soft component are electrons generated by  $\pi$ -mesons at the indicated latitude. An analysis of the experimental and calculated values for the latitude of  $51^\circ$  indicates the existence of an excess of electrons possessing ranges smaller than  $2-3$  g/cm<sup>2</sup>. This phenomenon, which is most pronounced at  $51^\circ$ , is most probably caused by  $\gamma$ -quanta emitted in the atmosphere in reactions involving neutron evaporation. The energy flux carried away by these surplus short-range electrons comprise  $\sim 10$  percent of the total energy flux of the electron component at this latitude. The magnitude of the cosmic ray energy fluxes at latitudes of  $2^\circ$ ,  $31^\circ$  and  $51^\circ$  was determined. On the basis of these data and also of data on the intensity of cosmic ray particles at the top of the atmosphere at the latitudes  $51^\circ$  and  $31^\circ$ , an expression was obtained for the primary-particle energy spectrum. The primary cosmic ray particle flux ( $N_p + N_a$ ) at the equator ( $2^\circ$ ) was found to equal  $0.48 \pm 0.04$  particles min<sup>-1</sup> cm<sup>-2</sup> sterad<sup>-1</sup>. (PA, v. 62, #2476)

**386. OBSERVATIONS OF NUCLEO-ACTIVE  $> 10^{13}$  ev COSMIC PARTICLES**

Murzina, E. A., Mikolskii, S. N., and Yakolev, V. R.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 35, pp. 1298-1300, November 1958

**387. INVESTIGATION OF NUCLEAR DISINTEGRATIONS PRODUCED BY CHARGED COSMIC RAYS**

Khrimyan, G. V.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 35, no. 5, pp. 1076-1082, 1958

Results of an investigation of nuclear disintegration products generated by the charged component of the cosmic radiation are presented. Some methods of separating nuclear disintegrations from showers produced by electromagnetic interaction of  $\mu$ -mesons are indicated. A differential momentum spectrum of secondary particles created in stars with  $n > 2$  was found. It is shown that for generated  $\pi$ -mesons the ratio  $N(\pi^+)/N(\pi^-)$  is equal to  $1.18 \pm 0.23$  in the momentum range from from 0.12 to 0.9 Bev/c. The  $\pi^-$ -mesons comprise  $53 \pm 5$  percent of secondary particles possessing momenta  $\geq 1$  Bev/c. The ratio of the number of charged to neutral star-producing particles with energies  $\sim 30$  Bev is  $1.2 \pm 0.16$ . (PA, v. 62, #2479)

**388. ON THE ANGULAR DISTRIBUTION IN DEUTRON DIFFRACTION SCATTERING**

Ivanchik, I. I.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 35, pp. 1050-1052, October 1958

**389. INELASTIC INTERACTION OF COSMIC-RAY PROTONS OF KINETIC ENERGIES ABOVE 7 Bev WITH CARBON AND HYDROGEN NUCLEI**

Alekseeva, K. I. and Grigorov, N. L.  
*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 35, no. 3, pp. 599-611, 1958

Inelastic interaction between cosmic ray protons of kinetic energy above 7 Bev (mean energy  $\sim 20$  Bev) and carbon and hydrogen nuclei was investigated at a geomagnetic latitude of  $31^\circ$ N at a stratosphere. The measurements were made with the aid of a telescope, inside which a lead filter and the graphite and paraffin targets were located, and a hodoscope system of counters surrounded the telescope and filters. A value of  $315 \pm 50$  millibarns was obtained for the proton-carbon inelastic interaction cross section. The proton-proton inelastic interaction cross section was  $32 \pm 10$  millibarns. The average number of charged penetrating particles in showers from carbon

was found to be  $4.2 \pm 0.5$  particles per shower and  $\sim 3.4$  particles per shower produced in hydrogen. (PA, v. 62, #2478)

**390. ON SOME SOURCES OF THE LOW-ENERGY ELECTRON-PHOTON COMPONENT OF THE COSMIC RAYS IN THE STRATOSPHERE**

Rapaport, I. D.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 34, no. 5, pp. 1306-1309, 1958

It is shown that part (20-30 percent) of the low-energy electron flux (range  $R < 1.7$  g/cm<sup>2</sup> of Al) observed in the cosmic radiation in the stratosphere is genetically related to the products of nuclear disintegrations. (PA, v. 61, #8086)

**391. STUDY OF HIGH-ENERGY NUCLEAR-ACTIVE PARTICLES WITH AN IONIZATION CHAMBER**

Zatsepin, G. T., Krugovŷkh, V. V., Murzina, E. A., and Nikolskii, S. I.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 34, no. 2, pp. 298-300, 1958

Nuclear-active particles possessing energies above  $10^{11}$  ev were studied at an altitude of 3860 m above sea level by means of ionization chambers placed under absorbers of various thicknesses and of a counter hodoscope. Integral spectra of ionization bursts in the chambers are presented and conclusions are drawn regarding the absorption mean free path in air and in lead of nuclear-active particles with energies  $> 10^{11}$  ev. (PA, v. 61, #8104)

**392. A STUDY OF SLOW  $\mu$ -MESONS IN THE STRATOSPHERE BY THE METHOD OF DELAYED COINCIDENCES**

Tulinov, V. F.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, no. 5, pp. 1163-1165, 1957

A study was made of the altitude dependence of  $\mu$ -mesons of energy  $\sim 100$  Mev at altitudes of up to 25 km at 51° and 31°N latitude. The spectra of meson generation in the atmosphere were found. (PA, v. 61, #6016)

**393. INTERACTION OF PARTICLES OF  $10^{12}$ - $10^{13}$  ev ENERGY WITH LIGHT NUCLEI**

Grigorov, N. L., Shestoporov, V. Ya.,

Sobinyakov, V. A., and Podgurskaya, A. V.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, no. 5, pp. 1099-1109, 1957

A study was made of the spectrum of large ionization bursts in 44 ionization chambers covered with a layer of lead of 10 and 12 cm thickness at an altitude of 3200 m above sea level. From the probability of observation of bursts accompanied by air showers, conclusions are drawn on the range of particles of  $\sim 10^{12}$  ev for interaction in air. There were cases of the simultaneous appearance of two and more bursts of commensurable magnitude in several chambers separated from each other (bursts with spatial structure). (PA, v. 61, #6018)

**394. SOLUTION OF KINETIC EQUATIONS FOR HIGH ENERGY NUCLEAR-CASCADE PROCESSES**

Gerasimova, N. M.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, pp. 637-644, September 1957

The altitude dependence of high-energy nuclear active particle and the spectrum of  $\mu$ -mesons produced in the decay of  $\pi$ -mesons are investigated. The elementary act is described hydrodynamically; Landau's function, in which account is made of a traveling wave in the hydrodynamic solution, is taken as the energy distribution function of the produced particles. (NSA, v. 12, #10,718)

**395. INVESTIGATION OF NUCLEAR DISINTEGRATIONS PRODUCED BY THE CHARGED COMPONENT OF COSMIC RADIATION**

Asatiani, T. L. and Khirmian, G. V.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, pp. 561-566, September 1957

The momentum spectrum of negative  $\pi$ -mesons from stars created by charged cosmic rays of  $\sim 30$  Bev energy has been obtained. The power exponent of the spectrum is  $\gamma = 1.46 \pm 0.2$ . The ratio of positive to negative  $\pi$ -mesons  $N_{\pi^+}/N_{\pi^-} = 1.67 \pm_{-0.53}^{+0.81}$  and the number of protons relative to the number of particles possessing a momentum  $p \geq 10^9$  ev/c is  $\sim 30$  percent. (NSA, v. 12, #2998)

**396. THE PROTON COMPONENT OF COSMIC RAYS AT SEA LEVEL**

Meshkovskii, A. G. and Sokolov, L. I.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, no. 2, pp. 542-544, 1957

Using a technique described in another paper (PA, v. 59, #8268) the spectrum of cosmic ray protons was measured in the momentum range from 0.31 to 0.55 Bev/c. The values of the intensities are compared with those obtained with the same apparatus at 3250 m above sea level, and the mean free path for absorption in air is thus deduced ( $L = 143.5 \pm 6.1$  g/cm<sup>2</sup>). This value is in good agreement with that obtained by other authors. A comparison with results obtained at sea level for protons with momenta larger than 0.5 Bev/c shows that the maximum of the spectrum lies between 0.5 and 0.6 Bev/c. (PA, v. 61, #4097)

**397. THE SOFT COMPONENT OF AN ELECTRON-NUCLEAR SHOWER AT AN ENERGY OF THE ORDER OF  $10^{14}$  ev**

Gremenitskii, I. M., Zhdanov, G. B.,

Tretyakova, M. I., and Shcherbakova, M. N.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, no. 1, pp. 282-283, 1957

The development of the electron-photon component of a shower initiated in a photographic emulsion by an  $\alpha$ -particle of energy  $8^{+3}_{-4} \times 10^{13}$  ev has been studied. The spatial and energy distributions of electron-position pairs, and the spatial distribution of electrons are given. The photon concentration and the energy flux near the shower axis was found to be higher than expected on the basis of measurements of angular distribution and transverse measurements. (PA, v. 61, #2381)

**398. INCONSISTENCY BETWEEN THE THEORETICAL AND EXPERIMENTAL  $\delta$ -SHOWER FREQUENCIES AT HIGH ENERGIES**

Chikin, P. S.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*  
(in Russian), v. 33, no. 1, pp. 56-58, 1957

The data on frequency of high-energy  $\delta$ -electron production by cosmic ray  $\mu$ -mesons are classified. Small underground ionization bursts are computed. All the data point to a contradiction between theory and experiment at energies  $\geq 5 \times 10^8$  ev. (PA, v. 61, #3213)

(See also entries no. 60, 87, 88, 100, and 162)

## II. ČERENKOV RADIATION

### A. Theory

#### Periodicals

399. THE VAVILOV-ČERENKOV EFFECT AND ITS APPLICATION  
Bolotovskii, B. M. and Laikin, E. N.  
*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk* (in Russian), v. 69, no. 4, pp. 693-703, December 1959

A review of a book by J. V. Jelley entitled "Čerenkov Radiation and Its Applications."

400. SOME PROBLEMS ON THE THEORY OF RADIATION DURING TRAVEL THROUGH AN ENVIRONMENT WITH A VELOCITY SURPASSING THE SPEED OF LIGHT  
Ginzburg, V. L.  
*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk* (in Russian), v. 69, no. 4, pp. 537-564, December 1959

401. THEORY OF THE VAVILOV-ČERENKOV EFFECT  
Bolotovskii, B. M.  
*Akademii Nauk SSSR, Uspekhi Fizicheskikh Nauk* (in Russian), v. 62, no. 3, pp. 201-246, 1957

The survey of the topic by J. V. Jelley (*Progress in Nuclear Physics*, v. 3, p. 84, 1953) emphasized the experimental side. The emphasis in the present paper is intentionally upon the theoretical aspects of the subject and is therefore complementary to Jelley's survey. The first part deals with the Vavilov-Čerenkov effect in an isotropic medium, while the second half is concerned with the effect in crystals. (PA, v. 61, #5057)

402. ELEMENTARY CONSIDERATIONS ON THE DYNAMICS OF LIGHT WAVES  
Gyorgyi, G.  
*American Journal of Physics*, v. 28, no. 2, pp. 85-88, February 1960

An elementary treatment of the dynamical aspects of light refraction and Čerenkov radiation is given.

403. RADIATION OF PARTICLES WITH SPEEDS GREATER THAN THAT OF LIGHT  
Tamm, I. E.  
*American Scientist*, v. 47, no. 2, pp. 169-177, June 1959

A discussion of the history of the discovery of the phenomena and some applications to detection of cosmic rays and plasma physics.

404. DIRECTIONAL OBSERVATIONS OF 5 Kc/s RADIATION FROM THE EARTH'S OUTER ATMOSPHERE  
Ellis, G. R. A.  
*Journal of Geophysical Research*, v. 65, no. 3, pp. 839-843, March 1960

Low-frequency radio noise bursts associated with geomagnetic disturbances have been observed with a network of direction-finding receivers in southeastern Australia during September and October 1959.

405. THE ČERENKOV EFFECT IN COMPOSITE (ISOTROPIC) MEDIA  
Sayied, A. M.  
*Physical Society, Proceedings of the, London*, v. 71, no. 459, Part 3, pp. 398-404, March 1, 1958

The Čerenkov radiation emitted by a fast-charged particle moving through one medium and in the vicinity of another medium has been theoretically investigated. A simple geometry has been considered with special reference to the case of Čerenkov radiation at microwave and radio-frequency regions. The effect of the phenomena of coherence on the output of the emitted radiation in these cases has also been briefly outlined.

406. ČERENKOV RADIATION IN THE ATMOSPHERE  
Jelley, J. V.  
*Planetary and Space Science*, v. 1, no. 2, pp. 105-111, April 1959



407. RADIATION FROM PARTICLES EXCEEDING THE VELOCITY OF LIGHT, AND SEVERAL APPLICATIONS OF IT IN EXPERIMENTAL PHYSICS

Čerenkov, P. A.

*Science and Culture*, Calcutta, v. 25, no. 5, pp. 281–286, November 1959 (Abstracted in *Electronic Technology*, v. 37, no. 3, p. A42, March 1950)

The history of the discovery and interpretation of Čerenkov radiation is outlined. The application of radiation measurements in the investigation of cosmic ray showers is discussed.

408. POLARIZATION OF ČERENKOV RADIATION

Sokolov, A. A. and Loskutov, Iu. M.

*Soviet Physics-JETP*, v. 5, pp. 523–525, October 1957

409. POLARIZATION PROPERTIES OF ČERENKOV RADIATION

Loskutov, Iu. M.

*Vestnik Moskovskogo Universiteta* (in Russian), v. 12, no. 5, pp. 101–104, 1957

The influence of particle spin on the polarization of emitted radiation was studied in relation to some particle properties. Calculations of radiation intensity were made for linear and circular polarizations. (NSA, v. 12, #16,847)

410. CONTRIBUTION TO THE THEORY OF TRANSITION RADIATION

Garibyan, G. M.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 33, no. 6(12), pp. 1403–1410, 1957

Transition and Čerenkov radiation arising when a charged particle moves in succession through two media differing in dielectric and magnetic properties are considered. The cases when the particle enters a medium from vacuum or vacuum from a medium are discussed in detail. (PA, v. 61, #5969)

411. ON THE RADIATION OF A POINT CHARGE MOVING UNIFORMLY ALONG THE SURFACE OF AN ISOTROPIC MEDIUM

Morozov, A. I.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 32, no. 5, pp. 1260–1261, 1957

Formulae for a non-dispersive medium are used to obtain the Čerenkov radiation of, and force on, the particle. These are compared with results for a filament, obtained earlier. (PA, v. 61, #660)

412. THE APPLICATION OF LEONTOVICH'S BOUNDARY CONDITIONS TO THE ČERENKOV RADIATION THEORY

Morozov, A. I.

*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* (in Russian), v. 33, no. 4(10), pp. 933–935, 1957

The field of charge moving above a flat boundary is computed using Leontovich's approximate boundary conditions. (PA, v. 61, #5170)

**B. Instrumentation****Reports****413. TOTAL ABSORPTION ČERENKOV DETECTORS AND A MEASUREMENT OF ENERGY FLOW IN THE EXTENSIVE AIR SHOWER**

Matano, T., Miura, I., Oda, M., Suga, K.

Tanahashi, G., and Tanaka, Y.

April 10, 1958

Tokyo, University of, Institute for Nuclear Study, INSJ-9 (36 pp.)

Some details regarding Čerenkov detectors which were designed for the measurement of the energy flow of electronic components in the extensive air shower are described. The principle of the detectors is the utilization of the Čerenkov radiation from electrons of cascade showers produced in the heavy material, viz. lead glass and lead nitrate solution in the present study. The lateral distribution of the energy flow carried by the electronic and nuclear-active components was studied with these detectors, and the distribution function was tentatively concluded to be  $r^{-1.1 \pm 0.2} f(\gamma)$ , where  $f(\gamma)$ , is the lateral distribution function of the density of electrons. (NSA, v. 12, #11,596)

**Periodicals****414. RESULTS OF SCIENTIFIC INVESTIGATIONS MADE BY SOVIET SPUTNIKS AND COSMIC ROCKETS**

Krasovskii, V. I.

ARS Journal, v. 30, no. 1, pp. 27-33, January 1960

A description of the instruments placed by the geophysicists and astrophysicists on the Soviet space vehicles to research different properties of the upper atmosphere and cosmic space, hard electromagnetic and corpuscular radiation of the Sun, interplanetary dust and gaseous medium, magnetic fields, cosmic rays and planets and their satellites.

**415. A DIFFERENTIAL ČERENKOV COUNTER**

Baldwin, D. E., Burrowes, C., Caldwell, D. O., et al.

IRE Transactions on Nuclear Science, v. NS-5, no. 3, pp. 177-178, December 1958

A beam of parallel particles of given velocity traversing a transparent radiator gives off Čerenkov radiation at

a unique angle with respect to the beam direction independently of the point of traversal. Such light can be brought to a ring focus. A Čerenkov counter has been built using this principle. Velocity definition is obtained by using a ring diaphragm on the face of a photomultiplier. The greatest velocity definition is obtained for small angle Čerenkov light. To change the velocity selection without changing the optics, the index of refraction of the radiator is varied. The index of refraction may be varied by changing the pressure of a gas near its critical point. The working fluid is Fluorochemical FC-75. The index of refraction of FC-75 can be varied continuously from  $n = 1.15$  to  $n = 1.01$  at a temperature of  $250^\circ\text{C}$  by changing the pressure. The counter has been tested using  $1.8 \text{ Bev/c } \pi$ -mesons from the Brookhaven Cosmotron; the counting rate vs. pressure of the FC-75 has a full width corresponding to less than  $\Delta\beta = 0.01$ . (NSA, v. 13, #3770)

**416. PHOTOMULTIPLIER COUNTERS IN HIGH-ENERGY PHYSICS EXPERIMENTS**

Moyer, B. J.

IRE Transactions on Nuclear Science, v. NS-3, no. 4, pp. 107-111, November 1956

Techniques in the use of photomultipliers in high-energy nuclear physics are presented by the description of experiments that have been prominent recently. The applications involve the use of photomultipliers with attendant amplification at the limit of present possibilities of time resolution. Such applications include measurements of time-of-flight, measurement of lifetime of heavy unstable particles, and the elimination of background effects in the pulsed radiation fields of high-energy accelerators. The need for the development of large fast-rising signals from events of small light output, such as Čerenkov light pulses, is made apparent, and a discussion of the performance desired from electron multipliers in view of contemplated experiments is presented. (PA, v. 62, #2555)

**417. ČERENKOV COUNTERS IN HIGH ENERGY PHYSICS**

Wiegand, C. E.

IRE Transactions on Nuclear Science, v. NS-5, no. 3, pp. 77-81, December 1958

Emphasis is on the practical design of velocity-sensitive devices. The performance and problems associated with three types of detector are considered: simple velocity threshold counters and wide-band and narrow-band

velocity selectors. The limitation in resolution of practical velocity-sensitive counters in high energy experiments arises mainly from the characteristics of the beams which must pass through their radiators. These limitations include divergences in the direction of the beam particles, multiple Coulomb scattering, and changes in velocity of particles as they pass through the Čerenkov radiator. Methods of coupling radiators to multiplier phototubes include direct optical contact, specular reflection, and diffuse reflection. Magnesium oxide is an excellent diffuse reflector and methods of its application are given. Statistical fluctuations in the small numbers of photo-electrons produced from Čerenkov radiators limit the accuracy with which the times of passage of individual particles are determined. (PA, 62, #4871)

**418. RELATIVE SCINTILLATION INTENSITY  
OF SOME ČERENKOV COUNTER MEDIA**

Madey, R. and Leipuner, L.

*IRE Transactions on Nuclear Science*, v. NS-3,  
no. 4, pp. 61–62, November 1956

Selected transparent media were bombarded with a 40 Mev alpha-particle beam. The ratio of the photomultiplier output current to the alpha-particle beam current was taken as a measure of the relative scintillation intensity. The output current from an RCA type 6342 photomultiplier was read on a 50  $\mu\text{A}$  (full scale) meter. The alpha particle beam current was monitored by counting alpha particles elastically scattered from a 0.005-in. gold foil. Preliminary results on the light output from some media relative to that for distilled water are tabulated. Background appeared to give negligible contribution to the scintillation intensity. The background measurement was made by stopping the alpha beam with a  $\frac{1}{16}$ -in. aluminium plate inserted ahead of the substance studied. (PA, v. 62, #2553)

**419. CHANGES IN THE LOW-RIGIDITY PRIMARY  
COSMIC RADIATION DURING THE LARGE  
FORBUSH DECREASE OF MAY 12, 1959**

McDonald, F. B. and Webber, W. R.

*Journal of Geophysical Research*, v. 65, no. 2,  
pp. 767–770, February 1960

Of particular interest are data obtained relating to the rigidity of composition of primary cosmic ray particles on two balloon flights during this period. The detector

used in these experiments consisted of a lucite Čerenkov detector and a NaI scintillation counter.

**420. LARGE-AREA DISTILLED WATER  
ČERENKOV COUNTER**

Srivastava, B. N.

*Journal of Scientific and Industrial Research*,  
India, v. 17B, no. 7, pp. 281–282, July 1958

A volume of distilled water is viewed by a single photomultiplier. The efficiency of the counter as a function of distance of the incident cosmic-particle from the photomultiplier is determined, using two G.M. counters, one above and one below the volume, by comparing the double coincidence rate of these two counters with the triple coincidence rate with the Čerenkov counter. Efficiency is high within a distance of 6 in., but falls off rapidly beyond. (PA, v. 62, #498)

**421. A TOTAL-ABSORPTION ČERENKOV  
COUNTER FOR PHOTONS OF ABOUT  
100 Mev ENERGY**

Moffatt, J. and Stringfellow, M. W.

*Journal of Scientific Instruments*, v. 35, no. 1,  
pp. 18–20, January 1958

The counter uses a cylinder crystal of thallous chloride 12 cm long and 9.3 cm in diameter viewed by a photomultiplier tube, and is capable of giving pulses of up to 3 v in height without serious departure from linearity. The pulse height resolution for 78 Mev photons is 34 percent, and both the mean pulse-height and resolution remain constant to within 5 percent over an entrance aperture 5 cm in diameter. The performance of the counter is discussed in some detail, and it appears that the resolution is limited principally by strong absorption of ultraviolet light in the crystal. (PA, v. 61, #3277)

**422. AIR SHOWERS OF SIZE GREATER THAN  
10<sup>5</sup> PARTICLES. I. CORE LOCATION AND  
SHOWER SIZE DETERMINATION**

Brennan, M. H., Millar, D. D., and Wallace, C. S.

*Nature*, v. 182, pp. 905–911, October 4, 1958

An apparatus is described which consists of a 70 m  $\times$  30 m array of scintillators associated with a cloud chamber Čerenkov detector, geiger counters and neutron monitor. Data are recorded on teleprinter tape which is fed into a digital computer. This determines the core posi-

tion and size of each shower by varying the parameters of an assumed lateral structure function. An integral shower spectrum in agreement with that of other workers was found, despite the fact that the apparatus is designed for shower structure study rather than for absolute intensity determination. (PA, v. 62, #2462)

**423. AIR SHOWERS OF SIZE GREATER THAN  $10^5$  PARTICLES. II. ČERENKOV RADIATION ACCOMPANYING THE SHOWERS**

Brennan, M. H., Malos, J., Millar, D. D., and Wallace, C. S.

*Nature*, v. 182, pp. 973-977, October 11, 1958

The Čerenkov detector associated with the apparatus of Part I (see preceding abstract) is described. It was found that Čerenkov light could be detected at angles up to 30 deg from the air-shower axis. This indicates that the shower particle angular distribution cannot be ignored. (PA, v. 62, #3463)

**424. AN ENERGY SENSITIVE ČERENKOV DETECTOR WITH IMPROVED OPTICAL FOCUSING**

Huq, M and Hutchinson, G. W.

*Nuclear Instruments*, v. 4, no. 1, pp. 30-35, January 1959

A Čerenkov detector is described having improved energy-selecting properties for protons of energy about 900 Mev. Good focusing from an extended area of a spherical reflecting surface has been realized by minimizing astigmatism in the optical system. The light is produced in a liquid radiator and detected by photomultipliers used in coincidence. The energy resolution is largely determined by the dimensions of the optical stop used. It is about  $\pm 4$  percent in the instrument constructed. (PA, v. 62, #7224)

**425. SIMPLE ČERENKOV DETECTOR FOR THE MEASUREMENT OF THE ENERGY OF RELATIVISTIC CHARGED PARTICLES**

Huq, M.

*Nuclear Instruments*, v. 2, pp. 342-347, May 1958

A detector using a cone-shaped perspex radiator for the measurement of the energy of protons from a proton synchrotron is described. The over-all resolution obtained was  $\pm 13$  percent most of which is contributed by the

sensitivity of the detector to the width and angular spread of the beam. With ideal beam conditions the resolution is expected to be  $\pm 6$  percent. (NSA, v. 12, #10,833)

**426. EFFICIENT DETECTOR FOR HIGH ENERGY NEUTRONS**

Booth, N. E. and Ledley, B.

*Nuclear Instruments*, v. 1, pp. 345-350, December 1957

A detector of neutrons in the energy range 400 to 900 Mev has been constructed and studied. At 800 Mev its efficiency is 1 to 2 percent. It consists of a rod of perspex 10 cm in diameter and 50 cm long, one end of which is viewed by a photomultiplier. High energy incident neutrons are detected by observing the Čerenkov light emitted by charged secondary particles produced in the perspex. Since the average pulse height increases with incident neutron energy, the effective energy threshold may be raised by pulse height selection. Experimental results are presented for the dependence of the efficiency upon the energy and direction of secondary protons. The neutron detection efficiency has been calculated as a function of energy. (NSA, v. 12, #5522)

**427. HOW MUCH DO WAVE LENGTH SHIFTERS USED FOR ČERENKOV COUNTERS SCINTILLATE?**

Finocchiaro, G., Finzi, R., and Mezzetti, L.

*Nuovo cimento, II*, v. 15, no. 3, pp. 317-322, February 1, 1960

The increase in light output of liquid Čerenkov counters obtained by addition of wavelength shifting substances (as suggested by many authors) has been studied. It is shown that most of the observed increase is due to scintillation and not to actual wavelength shifting. Crystalline sodium salicylate coating of the counter walls has also been used for the same purpose. Its average quantum efficiency is found to be relatively high but practical use is limited by the fact that its reflectivity in the visible is lower than that of MgO.

**428. A ČERENKOV GAS COUNTER OF HIGH EFFICIENCY**

Beneventano, M., De Agostino, E., Galtieri, C. A., Rispoli, B., and Serra, A.

*Nuovo cimento, II* (in Italian), v. 12, no. 2, pp. 156-163, April 16, 1959

The performance of a CO<sub>2</sub> counter has been studied. The efficiency of the counter for cosmic ray  $\mu$ -mesons with momentum greater than 1.75 Bev/c has been measured as a function of gas pressure. Preliminary results give for the efficiency the value  $(96.7 \pm 1.1)$  percent at the pressure of 10.23 atm N.P.T. (PA, v. 62, #8415)

- 429. PERFORMANCE OF A LARGE AREA NON FOCUSING ČERENKOV COUNTER AND ABSOLUTE YIELD OF ČERENKOV LIGHT**  
Caglioti, G., Cervellati, R., and Mezzetti, L.  
*Nuovo cimento, II*, v. 11, no. 6, pp. 850-860,  
March 16, 1959

The design and the performance of a large area, comparatively thin toluene Čerenkov counter are described. The velocity resolution of non-focusing Čerenkov counters and its basic limitation, due to the Landau fluctuations in the emission of fast knock-on electrons, are discussed and compared with those of scintillation counters. The absolute yield of the Čerenkov light is evaluated from the measurements and found to be in good agreement with the theoretical yield.

- 430. A WAVE-LENGTH SHIFTER FOR ČERENKOV RADIATION IN WATER AND AQUEOUS LEAD SALT SOLUTION**  
Saito, K. and Suga, K.  
*Nuovo cimento, II*, v. 11, no. 4, pp. 600-605,  
February 16, 1959

An increase factor of 4.4 in photomultiplier pulse height was obtained by the use of pure amino G acid as a wave-length shifter for Čerenkov radiation in water. Further attempts were made to use this compound in a concentrated lead salt solution (1 M), and an increase factor of 1.8 was recorded, with the lead ion in the form of its ethylenediamine tetra-acetate (EDTA) complex.

- 431. HIGHLY DIRECTIONAL DETECTOR FOR COSMIC RAY PARTICLES**  
Hutchinson, G. W.  
*Nuovo cimento, II*, v. 11, no. 3, pp. 377-381,  
February 1, 1959

A relatively simple Čerenkov detector is described which will respond to relativistic charged particles only when their directions lie within a well-defined cone. The

limits of the cone are determined by the critical reflection of Čerenkov light from parallel faces of the radiator. The semi-angle of the cone may be chosen at will by varying the refractive indices used. It is suggested that the detector might be useful for attempts to detect a directional flux of uncharged primary particles at high altitudes. (PA, v. 62, #5973)

- 432. DETECTION OF HIGH ENERGY  $\mu$ -MESONS BY AN AIR ČERENKOV COUNTER**  
Giacconi, R., Blum, W., and Reynolds, G. T.  
*Nuovo cimento, II*, v. 11, no. 1, pp. 102-107,  
January 1, 1959

An investigation of the properties of air Čerenkov counters is described. A quantitative interpretation of the results is given.

- 433. A COINCIDENCE CIRCUIT WITH RESOLVING TIME OF 2.2  $m\mu$ sec AND DEAD TIME OF THE ORDER OF 5  $m\mu$ sec OF POSSIBLE APPLICATION IN NUCLEAR PHYSICS**  
Pellegrini, U., Rispoli, B., and Serra, A.  
*Nuovo cimento, II* (in Italian), v. 9, no. 1,  
pp. 171-183, July 1, 1958

A new high resolution coincidence circuit was studied for scintillation or Čerenkov counter experiments. The resolving time was found to be 2.2  $m\mu$ sec and the circuit is suitable for 5-fold or 6-fold coincidence arrangement. The circuit is given and the coincidence curve is shown. The circuit has a sensitivity of about 3 v and dead time of about 5  $m\mu$ sec. The characteristics of the circuit as well as the characteristics of conventional coincidence circuits were measured. (PA, v. 62, #506)

- 434. THE ČERENKOV EFFECT PRODUCED BY SINGLE PARTICLES IN GASES**  
Ascoli-Balzanelli, A. and Ascoli, R.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 1392-1408,  
December 1957

The problem of the detection by means of photomultipliers of the Čerenkov radiation produced by single particles in gases is studied. It is shown that a high efficiency may be obtained with not too big detectors, provided that each pulse due even to one photoelectron may be detected. Experiments are described which show that

such use of a photomultiplier is possible, and that an efficiency in agreement with the developed theory has been obtained with an 80 cm long detector filled with air at N.T.P. These experiments allow also a good determination of the number of emitted photons, and the result is in agreement with Tamm's theory. Some results obtained with freon 12 instead of air are also reported. (NSA, v. 12, #6078)

- 435. A  $p, \gamma$  COINCIDENCE METHOD FOR THE MEASUREMENT OF  $\pi^0$  PHOTOPRODUCTION**  
John, W. and Stoppini, G.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 1206-1210,  
November 1957

A method was developed to measure differential cross sections for photoproduction of neutral pions from hydrogen below 260 Mev incident photon energies. The recoil protons are detected in coincidence with one of the decay  $\gamma$  rays of the pion. The proton counter telescope utilizes a proportional gas counter as transmission counter. A lead glass Čerenkov counter detects the  $\gamma$  rays. A thin liquid hydrogen target with Mylar walls is used. Some cross sections measured at 90 deg in the center of mass are presented. (NSA, v. 12, #4340)

- 436. ON THE IMPULSES PRODUCED BY COSMIC RAYS IN PHOTOMULTIPLIERS**  
Amaldi, U., Jr.  
*Nuovo cimento, II* (in Italian), Series 10, v. 6,  
pp. 946-952, October 1957

The pulses produced in a photomultiplier (Dumont 6291) by the traversal of the fast ionizing particles of the cosmic radiation was studied by means of a coincidence arrangement, through careful analysis of the pulse-height distributions obtained in various conditions. The contribution of the Čerenkov effect in the glass of the window has been clearly established through its directional properties. The average pulse height of a Čerenkov pulse is  $\sim 5$  photoelectrons. An upper limit for the contribution of isotropic scintillation is evaluated, and the possible contribution of the mechanism of direct extraction of electrons from the photocathode and the dynodes is discussed. (NSA, v. 12, #4334)

- 437. A ČERENKOV COUNTER AS HIGH ENERGY PHOTON SPECTROMETER**  
Filosofo, I.  
*Nuovo cimento, II*, Series 10, v. 6, pp. 701-709,  
September 1957

A Čerenkov counter designed as high energy  $\gamma$  spectrometer is described. Lead glass is used as a medium in which the shower from a  $\gamma$  is both produced and absorbed. The incident energy is measured by means of the Čerenkov light produced in the medium by the electrons of the shower. The counter has been calibrated with electrons of energies up to 275 Mev and has shown high efficiency, linear response with the energy and energy resolution from  $\pm 28$  percent at 80 Mev to  $\pm 17$  percent at 275 Mev. Possible improvements of this type of instrument are discussed. (NSA, v. 12, #1528)

- 438. PROTON COMPONENT OF THE PRIMARY COSMIC RADIATION**  
McDonald, F. B. and Webber, W. R.  
*Physical Review, The*, v. 115, no. 1, pp. 194-205,  
July 1, 1959

The proton component has been studied at high altitudes on a series of balloon flights at various latitudes using the Čerenkov scintillation-counter technique. Results are discussed.

- 439. STUDY OF GEOMAGNETIC CUTOFF ENERGIES AND TEMPORAL VARIATION OF THE PRIMARY COSMIC RADIATION**  
McDonald, F. B.  
*Physical Review, The*, v. 107, no. 5, pp. 1386-1395,  
September 1, 1957

The results of a series of six Skyhook balloon flights with combination Čerenkov-scintillation detectors, are used to study spectral cutoffs as a function of latitude and to observe some aspects of temporal variations at high altitude of the alpha-particles of the primary cosmic-radiation. Observed cutoff energies are found to be in strong disagreement with geomagnetic theory. In one large cosmic ray decrease the very low-energy portion of the cosmic ray energy spectrum (300-600 Mev/ nucleon) does not seem to be strongly affected. (PA, v. 61, #222)

**440. MEASUREMENT OF ELECTRON BEAM  
ENERGY USING A GAS ČERENKOV  
DETECTOR**

Bhiday, M. R., Jennings, R. E., and Kalmus, P. I. P.  
*Physical Society, Proceedings of the, Great Britain*,  
v. 72, Part 6, pp. 973–980, December 1958

It is shown that the energy of a monoenergetic beam of fast electrons can be accurately determined by using a variable-pressure gas Čerenkov detector. A description of a simple detector of this type, and results taken with a 4.5 Mev electron beam, are given. (PA, v. 62, #2397)

**441. PULSE HEIGHT DISTRIBUTION OF  
ČERENKOV COUNTERS**

Wagner, R. J.  
*Review of Scientific Instruments, The*, v. 31, no. 3,  
pp. 271–278, March 1960

The problem of determining the distribution of path lengths of an isotropic flux of particles passing through a cylinder is solved analytically. The distribution function for some special cases of shielded cylinders also is discussed.

**442. LUMINESCENT EFFECTS IN PHOTO-  
MULTIPLIER TUBE FACES AND  
PLEXIGLAS ČERENKOV DETECTORS**

Anderson, K. A.

*Review of Scientific Instruments, The*, v. 30, no. 10,  
pp. 869–873, October 1959

By means of 20 to 35 Mev proton beams obtained from the University of Minnesota Linac, luminescent effects in Plexiglas Čerenkov detectors have been investigated. It was found that 1 percent of the protons entering the detector produced light pulses which overlapped the  $\mu$ -meson Čerenkov light distribution. These light pulses correspond to energy losses in a sodium iodide crystal of mainly less than 20 kev. Luminescent effects in the glass face of the particular photomultiplier employed were also studied and found to be quite large.

**443. GAS ČERENKOV COUNTERS**

Atkinson, J. H. and Perez-Mendez, V.  
*Review of Scientific Instruments, The*, v. 30, no. 10,  
pp. 864–868, October 1959

A gas Čerenkov counter is described which is suitable for charge-particle detection in the Bev region ( $\beta$  from 0.980 to 0.999). Calibrations of the counting efficiency are included along with a table of indices of refraction of suitable gases. The use of this counter as a threshold detector to discriminate between elastic and inelastic pions in the momentum range of 1 of 2 Bev/c is discussed. Use of the counter to differentiate between charged particles of different mass in a momentum-analyzed beam is also considered.

(See also entries no. 133 and 179)

### C. Measurements

#### Reports

444. BASIC SCIENCES. SECTION 4 [of]  
SYMPOSIUM ON THE PEACEFUL USES  
OF ATOMIC ENERGY IN AUSTRALIA,  
1958, HELD IN SYDNEY IN JUNE 1958  
Atomic Energy Commission, Australia  
NP-6829 (Section 4) (19 pp.)

A detector array for study of air showers of  $10^5$  to  $10^7$  particles is described. The punched paper tape data recording device is also described. Experiments in which the zenith angle distribution of air showers in the range  $10^5$  to  $10^7$  particles was obtained are reported. The results of studies of the Čerenkov light from air shower particles during passage through the atmosphere are given. Molecular iodine containing  $I^{131}$  was used to free radicals in hydrocarbons under ionizing radiation in high vacuum. The possibilities of using the  $Fe^{56}$  ( $n, p$ ) reaction as a threshold detector for fast neutrons were investigated. (NSA, v. 12, #13,646)

445. A MEASUREMENT OF ENERGY FLOW IN  
THE EXTENSIVE AIR SHOWER

Matano, T., Miura, I., Oda, M., Suga, K.,  
Tanahashi, G., and Tanaka, Y.

June 13, 1957

Tokyo, University of, Institute for Nuclear Study  
INSJ-3 (11 pp.)

Electronic components of the extensive air shower develop cascade showers and dissipate energies in the material. Total amount of Čerenkov radiations emitted in the material is proportional to the sum of path lengths for these cascade showers that is again proportional to the energy carried by electronic components. Thus, the collection of Čerenkov light emitted in a thick material, which is as thick as essentially whole energy of electronic components dissipates as cascade showers, provides a means of measuring the energy flow in the extensive air shower. It is attempted in the present air shower project to measure the energy flow of the electronic component and Čerenkov detectors based on the above principle are prepared (called e-detector). Essential features of two kinds of e-detectors are given. (NSA, v. 12, #6663)